Eagle Eye Networks Thermal Cameras for Elevate Body Temperature Screening White Paper

April 24, 2020

Preface

This whitepaper addresses a topic that is currently receiving a lot of attention, a lot of engineering effort and is based on technology that is rapidly changing. There is a lot of difference in opinion and a lot of different perspectives on using thermal cameras to measure body temperature. Different parts of the world have different perspectives, practices, customs, regulations and laws. Many of these regulations and technologies are changing at a rapid pace given the current Covid-19 pandemic. At Eagle Eye Networks we are constantly reviewing new cameras, developing and testing new technology, and learning more about our customer needs.

We have attempted to capture some current and useful information in this document. The topic is complex, and we expect to update this document regularly to reflect new test results, technologies and other offerings.

Eagle Eye Networks Team
April 24, 2020

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Overview

Given the current Covid-19 pandemic, thermal cameras are receiving increasingly more interest. It is a natural idea to utilize a thermal camera to detect elevated body temperatures. Right now, the Internet is full of information on the subject (including brand new companies), but it's difficult to understand what is real, what is wishful thinking and what is exaggeration. At Eagle Eye Networks we have purchased a number of thermal cameras and have run a series of tests to determine what is practical with today's technology. This document details some of the testing we have done and some of our conclusions. We do not claim that our testing is comprehensive or perfect, but we hope, that in sharing it, we can help.

This document focuses on the application of thermal cameras to read human body temperature. However, it is important to note, that before the Covid-19 pandemic, thermal cameras, at least as it relates to video surveillance, were primarily used for detecting perimeter breaches. This use case does not require the same level of precision that a thermal camera detecting an elevated body temperature requires. Therefore, typical general-purpose thermal cameras in the market have an accuracy of +/- 5 degrees Fahrenheit, which is not accurate enough to detect elevated body temperatures.

It's also important to note that elevated temperature screening is not screening for coronavirus or for any other illness. In fact, some people who have a virus or illness may not have an elevated body temperature. Additionally, the majority of thermal cameras are not approved for medical use or approved by the FDA, but they may be well suited to provide an initial reading to allow appropriate personnel to perform follow up evaluation and potential diagnosis.

Executive Summary

Thermal cameras can be used to detect elevated temperatures in humans under the right conditions. Creating those conditions can be challenging, but it's not impossible or impractical. Our experience in testing has shown that the preferred solution includes cooperative subjects and limits measurement to a small number of people simultaneously. Given appropriate conditions we have tested cameras and found they consistently report temperatures within +/- 0.7 degrees Fahrenheit of measurements taken with a traditional thermometer.

System Components

There are various systems in the marketplace, however, most cameras that are connected to a traditional surveillance system include these:

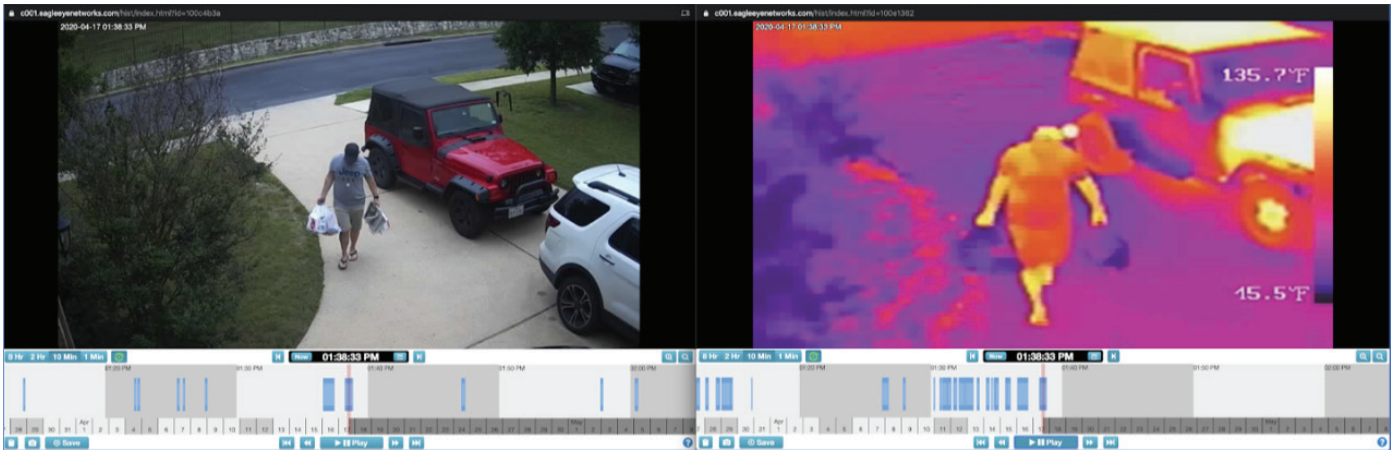
- Camera - Thermal Spectrum
- Camera - Visible Spectrum
- Thermal Calibration Unit (blackbody)
- Recording System/Video Management System
- Local Display Device (optional)

Figure 1: Thermal Camera

Cameras

Some of the more advanced thermal cameras are effectively two cameras in a single housing, these are known by several different names; Dual Spectrum & Bi-spectrum are the most common names. The image above (Figure 1) is a dual spectrum camera from Sunell that was designed to resemble a panda bear. This was originally deployed in Chinese schools where children would look at it as they entered.

Each camera produces a video stream, the visible spectrum camera works like most typical surveillance cameras. The thermal camera produces an image that is a visual representation of the different temperatures it has detected. These images can be either in grayscale or in color. Most cameras have several visual choices for how to represent the thermal data.



▲ Figure 2: Visual and Thermal Images from a traditional thermal surveillance camera

The images above (Figure 2) are from a dual spectrum thermal camera connected to the Eagle Eye Cloud VMS. This is a traditional video surveillance dual spectrum thermal camera, not a camera used to detect elevated body temperatures. There are a few things to note about the images. One is that the field of view is different. The visible camera can capture a wider field of view than the thermal camera. The visible camera has two vehicles in the field of view while the thermal camera only has one. The visible camera captures the street at the top of the image, while the thermal camera does not. The difference in camera field of view is quite common. Also, the thermal camera has a much lower resolution. The figures appear more "blocky." Thermal cameras today are generally much lower resolution that visible spectrum cameras.

Thermal Calibration Unit

A thermal calibration unit, sometimes referred to as a blackbody, is a device that maintains a specific temperature and does not reflect any energy from the surroundings. It is used as a constant point of reference for the thermal camera. Not all thermal cameras require a calibration unit, but many can make use of them if they are present. A calibration unit requires electrical power, but is not wired to the camera or the VMS/recorder. It is manually set at a prescribed temperature, and the thermal cameras are configured based on that temperature. Thermal calibration units are typically used when more precise temperature readings are required, such as in Elevated Temperature Screening. Some suppliers include a thermal calibration unit with the sale of the camera, but most do not. Calibration units are generally not present for most cameras connected to a video surveillance system. Many security industry personnel are not familiar with thermal calibration units or their use.

▲ Figure 3: Calibration unit showing the temperature it's emitting (in Celsius)

Recording System / Video Management System

The cameras are generally connected to a recorder. For this discussion we utilized the Eagle Eye Cloud VMS with its enhancements for support of Elevated Temperature Screening. The cameras are connected to an Eagle Eye Bridge. As shown above (figure 2), The Eagle Eye VMS records both the visible spectrum camera as well as the thermal camera. Additionally, Eagle Eye VMS captures the temperature measurement data that the camera generates. This means that the temperature is associated with a specific time, so searches can be performed based on the temperature, time or person. Notifications can be generated if the temperature is outside of a specified range. In other words, if the temperature is too high, a notification can be made. The Notifications can be delivered via various methods, but the most common is via email. Typical Notifications will have an image of the person, the temperature detected, as well as name and location of the camera that detected the high temperature.

Local Display Device

An optional local display is sometimes used to provide immediate awareness of detected temperatures. This is essentially a display monitor connected to the recorder showing the real time feed of the visual and/or thermal camera. This can be useful for awareness; however, it can be hard for a human operator to read every temperature reported in real time. It is more reliable to use a system that has alerts than to rely on a human reading a screen in real time. Many systems include a bell or an alarm if over temperature is detected.

Real World Situations

As different parts of the world reduce shelter in place guidelines many businesses and organizations look for solutions to provide environments where their employees, customers and visitors feel comfortable. There have been various news reports about companies using thermal cameras as a pre-screening tool to determine if individuals need further evaluation due to elevated body temperature[1]. Additionally, some businesses are using humans and a hand held thermometer to measure temperature.

Using a Hand Held Thermometer

Hand-held thermometers are generally available and fairly easy to use. Most families have one in their medicine cabinet. Using a one seems like a good idea, and it will likely work for a small number of people. However, as the number of people entering a building increase, the number of people performing screening must increase as well. The level of consistency and accuracy decrease as the number of screeners increase. In addition, with most hand-held thermometers the readings must be written down or transcribed into a computer system manually. It is difficult to develop a system and make this reliable. Furthermore, there is the risk to the screener, who needs to come close to the subjects being screened. We have had reports of screeners being uncomfortable in such proximity to so many people, and therefore not properly using the hand held unit, and thereby rendering the screening process completely unreliable.

Using an Automated Dual Sensor Thermal Camera System

An automated system certainly introduces some challenges, but it solves a number of issues. An automated system needs to be properly installed and calibrated, but then human error is largely removed. It is best used as a pre-screening operation. As subjects move through the screening area their temperatures are read automatically and, depending on the deployment, the temperatures may be stored and notifications generated if the temperature exceeds a specific threshold. These subjects could then be routed to another location for further screening.

This approach allows for a greater number of subjects to be screened and it reduces the reliance on human screeners. It does require a second step to further measure subjects that are identified by the prescreening, but the volume of subjects requiring secondary screening is a small fraction of the total number of subjects entering the building. The Dual Sensor solution is not perfect, the advantages and disadvantages, including cost, need to be weighed for each situation.

[1] https://www.reuters.com/article/us-health-coronavirus-amazon-com-cameras/exclusive-amazon-deploys-thermal-cameras-at-warehouses-to- scan-for-fevers-faster-idUSKBN2200HT

Eagle Eye VMS Integration and Features

The Eagle Eye Cloud VMS integrates with three specific aspects of most thermal cameras. Eagle Eye Networks will record the video stream, the thermal stream, and the temperature data for each subject. These are three independent data sources, that when combined can be powerful sources for reporting and alerting. The details of how this data is used and stored are described below.

Recording & Retention

The Eagle Eye VMS will record the video streams from the thermal cameras. This works with both single spectrum and dual spectrum cameras. These video streams are securely stored for a duration of 7 days up to five years, depending on the situation. Furthermore, parts of the video, or "clips," may be archived for a longer duration and easily shared with third parties.

Alerts & Reports

An administrator can configure alert thresholds and distribution lists for people to notify if a temperature exceeds that threshold. In other words, if there is an individual with a body temperature of 100 degrees Fahrenheit, a notification could be sent to a site manager. This alert could be an email or a push notification to their cell phone or tablet.

Reporting is also available to show a count of the number of subjects screened, and how many were above and below the threshold. Additionally, authorized users can view the video of the readings that caused the alerts.

User Access

Each user has their own unique ID and password to access the EE Cloud VMS. Eagle Eye Networks provides a robust, granular permission system. This allows specific cameras to be view only by specific users. This includes viewing video, making changes to settings, running reports and more. The system can be accessed with any modern web browser from a Windows or Apple computer or from dedicated iOS and Android mobile apps. Access can be from within the same building as the cameras, across town or even from a different country. Multiple users can access the same set of cameras and view the cameras at the same time, regardless of their location. In a Elevated Temperature Screening application the data related to people's health and temperature is private information. It is important that it be secured.

Simplified Setup

The Eagle Eye VMS has been designed for easy set up including the network. The first part is the connection from the camera to the Eagle Eye Bridge. This is accomplished by either using a PoE switch or using an Eagle Eye Bridge with integrated PoE. Simply use an ethernet cable to connect the camera to the switch, and then use another ethernet cable to connect the switch to the port labeled "CamLAN" on the bridge. This will allow the Bridge to manage the camera network, as well as isolate the cameras from the internet, providing a layer of cybersecurity.

The second part of the network setup is to connect the Bridge to the Internet. This is done by connecting an ethernet cable from the "WAN" port on the Bridge to your Internet connection (i.e. network router, WAN connection, cellular router, etc...). Once the physical connection is done, the configuration can be done from a laptop, mobile phone or tablet.

Not only can the initial configuration be performed easily, so can follow on maintenance.

Cyber Security

The Eagle Eye VMS was built with a foundation in cyber security with multiple facets of protection. The two key concepts relevant to thermal camera deployments are the cyber camera lockdown and the fact that Eagle Eye Bridges do not require inbound ports and will only communicate with the Eagle Eye Cloud.

The cyber camera lockdown isolates cameras from the internet. This is important because it prevents anyone accessing the camera directly from the internet and it blocks any communication from the camera out to the internet. In the past, some cameras have had malicious code installed. The cyber camera lockdown prevents this code from being able to communicate with any outside systems.

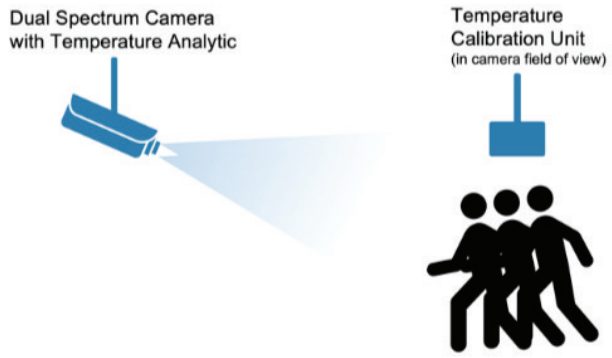
Additionally, the method the Bridge uses for communication with the cloud prevents external systems or malicious users from communicating with the Bridge, and by extension the cameras connected to the Bridge. The Bridge initiates the connection with the Eagle Eye Cloud. This connection is at secure tunnel that is authenticated via certificates. These methods and techniques ensure that only authorized users can view video and prevent compromise of the system. For additional cyber security information please see the Eagle Eye Cyber Security White Paper.[2]

Eagle Eye Elevated Temperature Testing Example #1

We have spent approximately 4 weeks testing thermal cameras for Elevated Temperature Screening. This is not an exhaustive study at this point. However, we have been testing in some real-world situations as well as lab comparisons. We have built up a reasonable body of knowledge. The testing we have done has been with individuals and pairs of subjects. We have not tested large groups of people. A number of tests and comparisons have been run. We will detail one such test below.

Setup #1

Our setup is indoors, close to the entrance of our office in Austin Texas. The cameras we tested recommend 10-13 feet of distance from the measurement point to the camera. Figure 4 below shows the equipment in place. The thermal cameras were calibrated with the calibration unit. They are connected to the Eagle Eye VMS using an Eagle Eye Bridge. There is also a local display monitor which shows the live view of the cameras including temperature readings. This setup is on a rolling cart, which is not ideal for a long-term installation, however it worked well for our tests.



▲ Figure 4: Diagram of camera with thermal calibration unit.

▲ Figure 5: Thermal camera setup in an office lobby

Test Methodology

As subjects entered the building, their temperatures were automatically captured by multiple thermal cameras. The subject's temperature would then be taken using a forehead contact thermometer. We used a QQcute MODEL FT-100A. This thermometer is rated with an accuracy of +/- 0.4 degrees Fahrenheit.

[2] Cyber Security and Cloud Video Surveillance https://www.een.com/cyber-security-cloud-video-surveillance/

Testing - Round One

We tested seven subjects three times each and recorded the results. Fortunately for our subjects nobody had an elevated temperature. Unfortunately for our testing this meant that we had to determine a way to simulate an elevated temperature. We tried several different methods including a hot towel and a hair dryer, but we ultimately settled on a ceramic. Ceramic retains heat reasonably well. The ceramic disk was submersed in hot water of a specified temperature (typically 100 to 105 degrees F). The ceramic disk would then be held to the forehead to simulate a warm body temperature. This is not a true and accurate simulation of an elevated body temperature, however it does test how the system behaves when it detects an elevated temperature.

Test Equipment – Round One

The following table outlines the different equipment used in the test.

Label	Device Type	Manufacturer	Model
Therm 1	Handheld Thermometer	QQcute	FT-100A
Camera 1	Thermal IP Camera	Sunell	SN-T5
Bridge	Recording Device	Eagle Eye	Bridge 304[3]

▲ Table 1: Testing equipment – round one

Test Results – Round One

We found the thermal camera was on average within +/-0.7 degrees Fahrenheit of the forehead thermometer. These tests were not conducted in a laboratory, they were conducted in the unpredictable environment of our office. So, while they're not scientific, they represent real world usage patterns.

Recently the FDA released updated guidance for Telethermographic Systems4. In this guidance their recommendation is to have a device that has an accuracy of +/- 0.9 degrees Fahrenheit.

Subject	Pass	Therm 1	Cam 1	Delta
A	1	98.0	97.3	0.7
B	1	97.5	97.1	0.4
C	1	98.0	97.2	0.8
D	1	98.1	97.1	1.0
E	1	98.0	97.2	0.8
F	1	98.0	97.3	0.7
G	1	98.1	97.3	0.8
A	2	98.1	97.2	0.9
B	2	97.7	97.1	0.6
C	2	97.6	97.2	0.4
D	2	97.7	97.2	0.5
E	2	97.7	97.2	0.5
F	2	98.2	97.2	1.0
G	2	98.1	97.3	0.8

▲ Table 2: Results from first round one

Summary of Differences	
Average	-0.71
Standard Deviation	0.20
Low	-0.4
High	-1.0

▲ Table 3: Round one test summary

As can be seen by Table 2, the thermal camera's results are always less than the hand held thermometer. The differences range from -.4 to -1.0 degrees Fahrenheit. One way to look at the data is to use the average difference of -0.7 degrees as an offset from the thermal camera to the hand held. Once that offset is applied then all of the thermal camera readings are within +/- 0.3 degrees of the offset. Using this methodology, one could simply adjust the target temperature they are looking for by -0.7 degrees and set the alerting threshold based on that number. In other words – if someone is looking for subjects with a temperature of 100 degrees, they could set the alert threshold to 99.3 degrees.

3 The Bridge 304 is used for this test, but any model of Eagle Eye Bridge or CMVR would work the same way

4 FDA Enforcement Policy for Telethermographic Systems During the Coronavirus Disease 2019 (COVID-19) Public Health Emergency Section D Paragraph 2a https://www.fda.gov/media/137079/download

Testing - Round Two

As of April 24, 2020 testing is still ongoing. This document will be updated as soon as results are available.

Thermal Cameras in The Market

There are many camera manufacturers that provide thermal cameras. This section is not meant to be an exhaustive guide, but rather a description of the more common manufacturers in the physical security market. Other cameras will be added as they become available.

Company	Thermal Camera	Dual Spectrum Camera	Eagle Eye Support
Axis	Yes	Yes	Most Models
Dahua	Yes	Yes	Some Models
Flir	In Progress	In Progress	In Progress
Hikvision	Yes	Yes	Some Models
Mobotix	Yes	Yes	Some Models
Sunell	No	Yes	Yes

▲ Table 4: List of thermal camera manufacturers

Conclusion

Our testing has shown that dual spectrum thermal cameras detect human body temperature to an accuracy of .7 degrees Fahrenheit in a real-world scenario. This is within the FDA guidelines of .9 degrees margin of error. We realize that this is not scientific proof and certainly not enough to be used exclusively for the safety of your employees, guests, visitors, friends or family. However, we do believe it to be a useful tool for initial screenings, in the proper environment. Like most tools it can be used as intended or it can be abused, it all depends on who is controlling it.

We believe that many businesses, organizations and possibly government entities will require some sort of temperature verification as shelter in place requirements are lifted and people return to work and recreation. Thermal cameras, properly configured, with appropriate alerting and reporting capabilities may be one way to achieve these goals.

Eagle Eye is committed to continue to investigate, innovate and deliver to help now, and in the future.

FAQ

Q: Are there any FDA guidelines to worry about?
A: The FDA has guidelines for what kind of devices can be used to measure a fever. In order for a company to market a device as 'fever detection' it must get a 510K certification. This is required even if the device is used for initial diagnosis with a second device used for final diagnosis. In other words, even if the camera is used to just identify people who should get their temperatures taken by a typical thermometer, the camera still needs the 510K certification.

Q: Where can I find more information about FDA guidelines?
A: Recently updated guidelines can be found on the official FDA website
https://www.fda.gov/media/137079/download

Q: Can this solution work on a cellular network?
A: Yes, the Eagle Eye VMS can work in a cellular environment. There is an option to store video locally, and only send alerts to the cloud. These alerts could be configured to be elevated temperatures.

Q: Can I use a thermal camera to see if someone is sick?
A: No, the thermal camera can only show elevated body temperature. Even if someone has a higher than normal temperature, they might not be sick. Only a doctor can determine if someone is sick.

Q: How many cameras do I need for my building?
A: That really depends on how many entrances you have, and how many you want to use. You will generally need one camera per active entrance, but you should consult with an Authorized Eagle Eye Reseller on your specific floorplan.

Q: How much does this feature cost in the Eagle Eye VMS?
A: This feature is being offered at no additional charge for the duration of the Covid-19 crisis.

Q: Is this something that Eagle Eye already had?
A: No, this is a feature that Eagle Eye developed in response to the Covid-19 crisis.

Q: How long does it take for Eagle Eye to send me an alert if there is an elevated temperature detected?
A: Generally, 1-2 seconds, although there may be some variation depending on network congestion.

Q: Many of the thermal camera manufacturers are from China, should I be concerned about cybersecurity?
A: We believe it is important to consider cybersecurity at all times, regardless of the country of origin of the cameras. That's why Eagle Eye has the Cyber Camera Lockdown feature that isolates cameras from the Internet.

Q: Can this system be fooled?
A: Absolutely. There are a lot of ways that people can trick the system into providing a false reading or even no reading at all. Environmental conditions play a significant role in the effectiveness of this system.

Contact Information

For more information about thermal cameras or cloud video surveillance please contact us at:

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Disclaimer

Eagle Eye Products are not designed to diagnose coronavirus, H1N1, SARS, or influenzas. Eagle Eye is not advertising cameras for use in the medical industry or for medical purposes. Thermal products can identify individuals in a population that display higher temperature. Thermal cameras do not find individuals experiencing coronavirus symptoms. There is no way to thermally detect an infected individual who has a normal body temperature. Only a licensed medical professional can determine if a warm individual has a medical condition. Eagle Eye cameras are not sold or marketed for any medical use.

Appendix A – Glossary and Terms

Blackbody – A common term for a thermal calibration unit (see below)

Dual spectrum thermographic camera – A camera that can record both visible and thermal spectrums.

Eagle Eye Bridge – An onsite device that manages video traffic from the camera to the Eagle Eye Cloud. Learn more here ***https://www.een.com/product/bridge-models/***

Eagle Eye Security Camera VMS – A cloud based video management system. This system supports thousands of different models of cameras and provides a platform to manage data associated with the video. Learn more hereàhttps: ***//www.een.com/product/cloud-vms-system-overview/***

Power over ethernet (PoE) – A networking standard that allow power to be delivered over the same cable as data. This is commonly used in IP cameras, IP phones and wireless access points.

Telethermographic system – A collection of individual components connected and configured to create a comprehensive system for reading temperatures.

Thermal calibration unit – A device that consistently emits a prescribed amount of electromagnetic radiation and is in thermodynamic equilibrium. In other words, a device that maintains a constant temperature level that is used as a reference point for a thermal camera.

Thermal camera – A camera that records the thermal spectrum

Thermal spectrum – The range of light wavelengths associate with infrared or heat. These wavelengths are not visible to the human eye and are generally in the 1,000 to 14,000 nanometer range.

Visible spectrum – also visual spectrum. The range of light wavelengths that can be seen by the human eye, generally 400-700 nanometers.

Appendix B – Temperature Conversion Table

In this document we primarily refer to temperatures in Fahrenheit. The system will work with both Fahrenheit and Celsius. We have included the following table for reference.

Fahrenheit	Celsius
105	40.6
104	40.0
103	39.4
102	38.9
101	38.3
100	37.8
99	37.2
98	36.7
97	36.1
96	35.6

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Eagle Eye Networks

Whitepaper on Thermal Cameras

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