ThermIS: Automation of Viral Symptom Detection

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Background

Ever since the commercialization of air-travel, viruses and infections have become harder to suppress. During an epidemic such as the recent Ebola outbreak, airports tighten security by manually screening each passenger for potential symptoms; however, this process is both slow and expensive. By creating and implementing an automated, non-intrusive system to screen potential passengers for elevated body temperatures, a common symptom of many infections, the screening of passengers could be made into a much more efficient and streamlined process.

Pyrexia, also known as fever, is a common symptom for viral and bacterial infections. Apart from pyrexia, symptoms of a viral infection can include diarrhea, nausea and muscle aches; however, these symptoms are difficult to detect without invading the privacy of the individual. Pyrexia can be detected in a non-intrusive manner by reading the temperature of an individual's forehead, given that the emissivity of skin on the forehead is highest.

Currently, there are systems that use thermal imaging to detect individuals who exhibit symptoms of pyrexia; however, these systems are very expensive, rendering them inaccessible to some institutions. As well, these systems still require a person to manually read the screen and determine if the individual exhibits symptoms, and manually make sure that the right person is chosen from the thermal image.

Purpose

The purpose of this project would be to create an inexpensive, non-intrusive early detection system for pyrexia, designed to complement the standard airport screening processes.

By detecting potential carriers in a viral outbreak, an epidemic can be controlled and suppressed, limiting the damage it can inflict.

Design Criteria

The system must be significantly less expensive than a thermographic camera, yet it must still accurately and non-intrusively determine bodily temperature automatically. The system must also streamline the alert process, minimizing the human error that may occur as a result of confusion.

Design/Procedure

The system consists of three key components: the facial detection, the aiming of the sensor and the thermal measurement itself.

The facial detection is carried out by a computer running computer vision software that is attached to an appropriate webcam. The software determines the position of the face on the screen and transposes those coordinates using the calibration subsystem into commands that the thermal measurement subsystem can understand.

The thermal measurement subsystem consists of a microcontroller, two servo motors and a pyrometer (thermopile with appropriate optics). The microcontroller relays the information between the computer and the servo motors, adjusting each to point the pyrometer in the right direction.

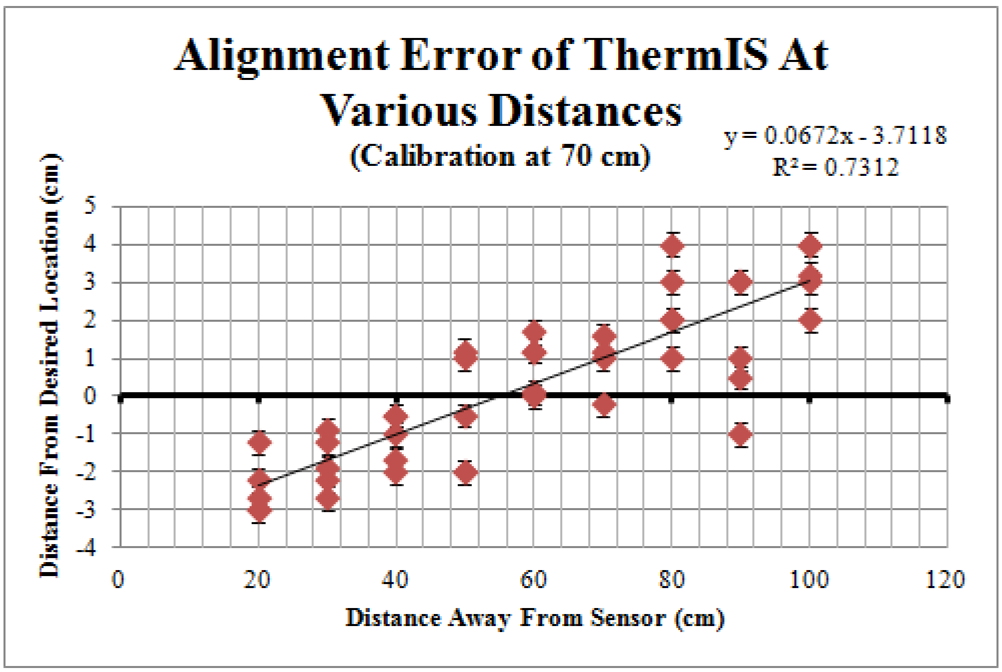
The pyrometer determines the temperature of the subject using infra-red radiation, and transmits this information back to the computer, to be analyzed by the software. If the software detects an abnormally high body temperature, it creates an alert that airport security can use to tell staff to further inspect the individual.

Challenges involved with creating this system include considering the latency in response, accuracy and thermometry. The latency of the system dictates the efficiency of the screening process, meaning that the system must be designed with a short response time from the moment of detection to the moment of alert. The accuracy of the system is influenced by how each sensor is physically placed, so a system of calibration is necessary to ensure accurate readings regardless of setup. Thermometry also provides challenges given that the optics on the pyrometer define its spot size, placing limitations on the fields of operation. As a result, algorithms were put in place to correct potential errors in thermometry that happen because of the optics. Given the design criteria, the system must also include an alert system that is simple yet capable of efficiently informing the operator which individuals exhibit symptoms.

Results and Observations

A test was created to determine how accurate the system is in pointing the thermal sensor at the desired location. The test uses the onboard laser instead of the pyrometer to visually determine the offset error of the servos. First, the system is calibrated within a plane at a specified distance. A printout of a face with an overlay of concentric circles is used to initiate the facial detection algorithm. The printout is used to test five points in the view: top-right, bottom-right, top-left, bottom-left, and center-center. The facial detection algorithm determines the point of interest on the face in the webcam view, which is then passed through the calibration object to determine the servo angles. The servos adjust to the required angles and the laser subsequently points at the calculated point of interest. The dot created by the laser is then measured using the concentric circles to determine its distance away from the point of interest. This distance is the error of the system, and this process is repeated for planes at varying distances away from the system, keeping the system at a constant calibration.

The results of this test are shown below. The graph shows the relationship between the distance the face is away from the system and the error of the servo configuration. The error is in the form of distance from the desired point, where a positive number means the laser is above the desired point, while a negative number means the laser is below. The general trend is positive, with a fairly strong correlation having a coefficient of determination of 0.73. This means that the error increases in a linear fashion depending on how far away the object is from the plane of calibration. This is likely due to the fact that there is a vertical offset between the thermal sensor and the web-camera.



Conclusions

The system meets the design criteria as it is significantly less expensive than a thermographic camera (ThermIS is ~$100 while a thermographic camera can range upwards of $2000), is non-intrusive and is fairly accurate. The system also provides a comprehensive alert that airport security can use to streamline their processes. This system may also see applications in medicine, as it is inexpensive enough to be set up in multiple hospital rooms to passively scan patients and determine whether a patient's condition has worsened.

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