وزارة التعليم العالي والبحث العلمي
جامعة ديالى
كلية العلوم
قسم علوم الحاسبات

تطوير نماذج قياس درجة حرارة الإنسان باستخدام K-mean وCNN

هذه الرسالة مقدمة الى كلية العلوم في جامعة ديالى وهي جزء من متطلبات نيل شهادة الماجستير في علوم الحاسبات.

تقدم بها الطالب

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Chapter One General Introduction

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General Introduction

1.1 Motivation

People today experience a wide range of illnesses as a result of their surroundings and lifestyle choices. Therefore, it is crucial to identify any sickness as soon as possible. Finding the right diagnosis for the ailment is, however, the most challenging stage. A new virus known as Corona Virus 2019 was discovered in Wuhan, China, in December 2019, and it spread quickly over the entire planet. This virus infected more than 70 million individuals in just one year, killing more than 1.6 million grandfathers [1]. There have been 6,853,702 fatalities worldwide as of this writing. Therefore, it is crucial to identify COVID-19 quickly and accurately to stop its spread and lower the number of fatalities. The WHO proclaimed the Coronavirus, a disease that infects every country in the globe, to be a pandemic on March 11, 2020. The probability of survival without needing intensive care from hospitals and centers is increased when sickness development is stopped early since this increases the effectiveness of the medical intervention. Health is very important since hospitals can only give so much lifesaving treatment. According to studies, Covid-19 pneumonia shares many clinical signs and symptoms with other types of pneumonia, however, Covid-19 patients are more likely than non-Covid-19 patients to experience liver function loss. This indicates that Covid-19 sickness is a serious illness with a significant chance of spreading to humans. One of the disease's hallmark signs is a high body temperature. Therefore, one of the best methods for identifying patients is temperature testing [2][3]. Whereas in the field of bioinformatics, there is a lack of data, especially in thermal videos, this data is scarce.

https://www.who.int

1.2 Overview of the Thermal Data

The first attempt to determine the quantity of infrared radiation from human skin was carried out 78 years after the discovery of "dark heat," even though infrared radiation was first identified in 1800. The first skin temperatures based on radiometry were computed in 1921 and physically measured in 1923. The development of infrared imaging as a military instrument followed, and it wasn't until the late 1950s that it was declassified for civilian use. In the late 1960s, the first commercial camera system with a lens was introduced. This invention reduced the noise and simplified the clinical camera, but temperature measurement remained difficult. Isotherms made it feasible to estimate temperature, and a research team in Bath, UK, established the thermographic index in 1972 as a technique based on calculating the area of isotherms inside a certain anatomical region. Around 1985, several manufacturers developed a cross-wire feature to show a spot temperature within the picture being shown. Personal computers and the ability to specify interest zones and use video frame processing tools were more widely accessible at this time. Before comprehensive digital technology became the norm, errors caused by the transfer from analog to digital were not noticed [4]. Thermal cameras have many applications, including early detection of diseases such as breast cancer, sinusitis, and arthritis. Also in industrial monitoring to detect defects in equipment, pipes and electrical wires. Also in improving security and safety in many industries, such as the oil, gas and petrochemical industries. Also in the exploration of natural resources such as oil, gas and minerals. Also in medicine to improve the diagnosis of skin diseases and functional imaging of the brain and nerves. Also in the solar energy industry to improve the efficiency of solar cells. Also in agriculture, figure (1.1) shows some thermal cameras [5].

FLIR-ONE-PRO

SEEK

UTI-120-M

640-100ZF

T-540

S118

HRC SERIES

A6780 SLS

F17H

Figure (1.1): Thermal cameras

1.3 Thermal Imaging System

A picture of the target's temperature distribution is called an infrared thermogram. Despite being used for military operations in the latter part of the 20th century, the second generation of infrared detectors [6], units that scan detectors with one to 10 elements made up the vast majority of thermal video framers used in medicine. Average speed rates ranged from 1 to 16 frames per second, with a temperature resolution of 0.5 C and a spatial resolution of around 5 mm at a target area of 50 cm2 [7]. However, with specifically designed equipment, high-resolution temperature (more than 0.1 C) and spatial accuracy (less than 0.1 mm) measurements were made achievable at frame rates of 25 Hz [8].

All detectors also required a cooling method, such as a sterling cooler, argon gas, or nitrogen. The 1990s saw the widespread use of the improved spatial resolution needed to detect the heat patterns caused by superficial skin vessels provided by focus plane array infrared cameras. Modern uncooled equipment is now capable of greater mobility and imaging of objects in the perpendicular view, i.e. With the camera in the vertical position, due to smaller camera units and the use of micro bolometers. High-sensitivity detectors, such as the quantum well-infrared photodetector, still need cooling, however. The non-uniformity value quantifies how much the temperature varies at each measurement location in the focal plane array. Considering that the specified requirement of 0.04% can only be met by a software modification of the raw data, reliable temperature readings need integrated computation.

IR thermography doesn't involve irradiation, unlike the majority of medical imaging techniques, hence there is no risk to tissue. It is possible to measure and utilize the infrared light that biological tissues release to determine temperature distributions. These estimations often account for radiation that is released by the environment and radiation that is reflected from the surroundings of the item. The continuous spectrum of radiant energy that makes up an object's infrared (IR) emission changes with its temperature (T, in kelvin) and wavelength; this phenomenon is referred to as spectral radiance (Lb) [9]. The ideal arrangement for a thermal imaging chamber is shown in figure (1.2) [10].

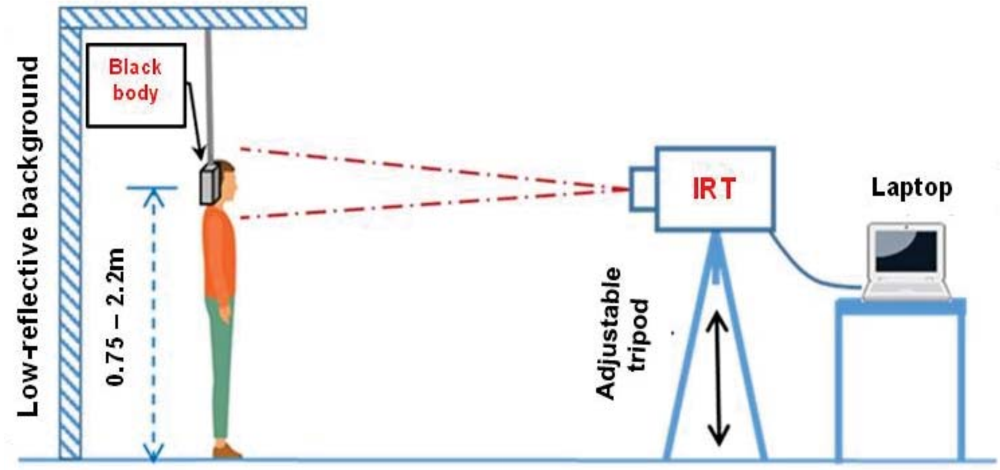

Figure (1.2): Block diagram demonstrates the proper thermal imaging room setup

1.4 Thermal Body Temperature Extraction

There are two primary methods for determining body temperature, an infrared thermometer is used to measure temperature over a short distance, and a thermography camera is used to remotely measure an object's temperature purposes. The inspector must be near pedestrians even though the infrared short-distance body temperature meter is simple to use and inexpensive. When the pedestrian is infected with the virus, it is unsafe. Thermal cameras that can monitor body temperature from a distance have been created to enable a secure assessment of body temperature [1].

Despite vaccination campaigns, the COVID-19 virus novels variations, such as Omicron, Delta, and others, continue to pose problems. To stop the transmission of this illness, the WHO advises wearing masks and checking your body temperature often and frequently in public areas. To lessen and prevent the transmission of this illness, these two procedures are adhered to with varied degrees of precision in many nations, particularly in public areas with high pedestrian traffic like airports, commercial markets, metro stations, railway stations, etc. [4].

1.4.1 Application Thermal Images Types

Thermal imaging is used in many military, medical, agricultural, industrial, and other applications, among the most popular applications are object classification [11], detection of prominent objects [12], detection of animals [13], night thermal photography [14], field of industry, object size detection [15], product temperatures [16], thermal conductivity [17], object detection [18], thermal object detection [19], and in the heat loss detection and location [20] see figure (1.3).

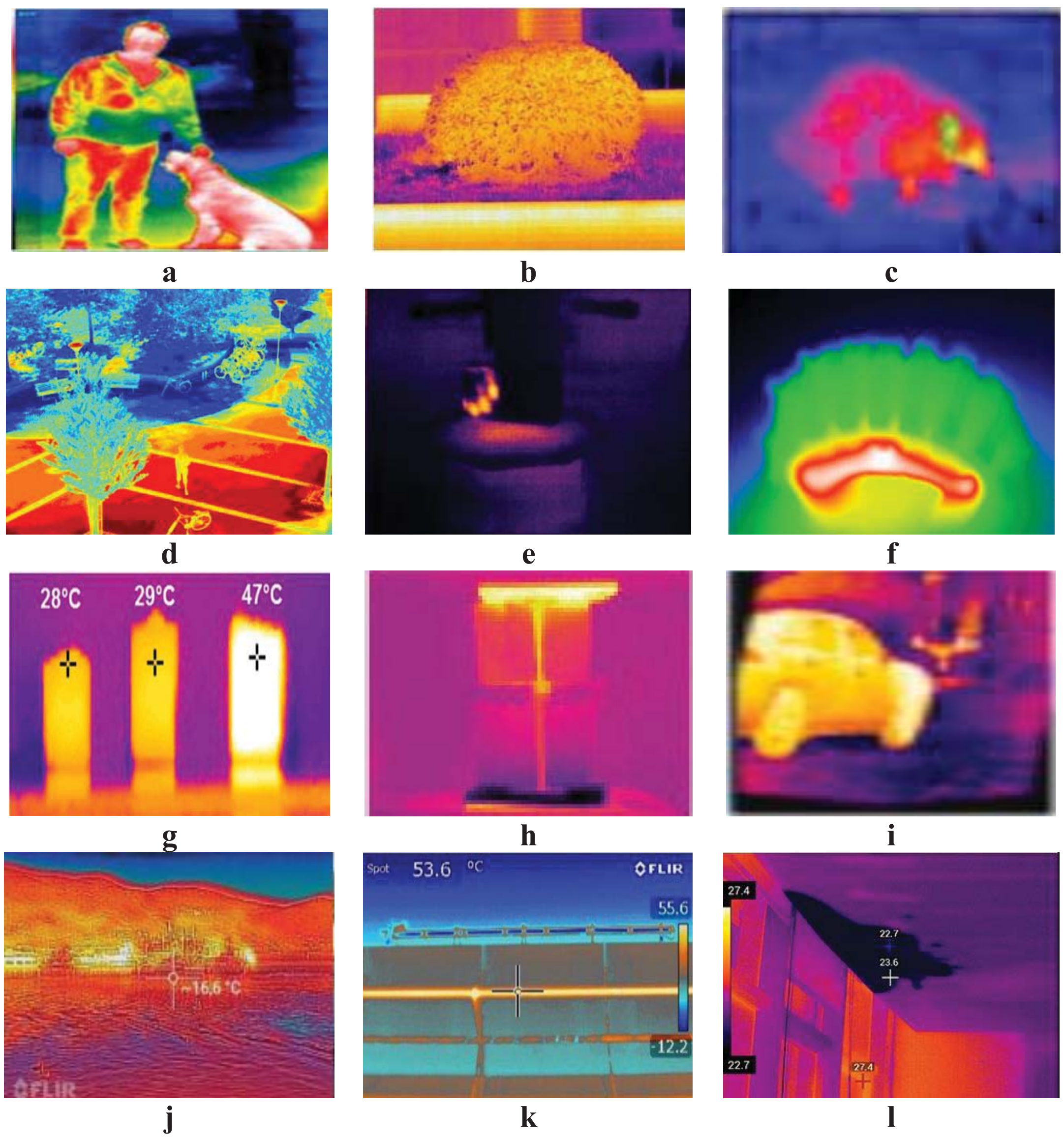

Figure (1.3): Some applications for thermal images

Figure (1.3) above shows a set of images for applications that use thermal imaging, where (a) represents object classification, (b) detection of prominent objects, (c) animal detection (d), night thermal imaging, and also in the field of industry where (e) represents size detection body, (f) temperatures of industrial products, (g)-(h) thermal conductivity, (i) detection of objects, (j) detection of thermal body, (k)-(l) detection of heat loss and its location.

1.5 Related Works

Recently, a number of researches tended to work on extracting people's temperatures, and reliance was made on specific areas of the human face. Some of these researches follow:

- Ma et al. 2021 [1] a cloud terminal collaboration system with a lightweight infrared thermometer model was made to safely and accurately monitor temperature even when a person's face is partially covered. A dual-lens camera with a thermal lens and an RGB lens was used to simultaneously record pairs of video frames. Then, using a mobile identification model based on a multitasking convolutional network (MT-CNN), it is proposed to perform face alignment and mask detection on RGB images. The forehead is the most accurate temperature measurement point after thermal images were generated using affine modulation of face charts on RGB video frames. Real-time uploads of acquired data to the cloud to get around COVID-19. The detection pattern is only 6.1M and the average detection speed is 257ms. At a distance of 1 meter, the error in measuring indoor temperature is about 3%. That is, the proposed system can realize real-time temperature measurement in public places.
- Katte et al. 2022 [3] after identifying the face and masks from the visual camera images using conventional techniques, the temperature

measurements were extracted from the thermal imaging cameras. Due to the fact that the visual video framer is the primary medium used in these applications, they can only be used in well-lit settings. The sole reliance on thermography in this inspection process makes this technique photochromic. However, it is difficult to develop such systems due to the scarcity of open source datasets. With the aim of recognizing faces and masks and allowing an effective automated screening strategy for COVID-19 in public spaces. They presented the NTIC dataset, which they built and used to train their algorithms and which were grouped in 8 distinct locations. Their results show that the use of thermal imaging is as effective as visual imaging only in the presence of high illumination. This performance remains the same for thermal images even in low-light conditions, while performance using trained visual classifiers showed a degradation of more than 50%.

- Makino et al. 2023 [2] A system for assessing the capabilities of infrared imaging, also known as thermography, evaluated symptoms and early indications using thermal video frames of different facial areas of subjects, and then analyzed their body temperature as a diagnostic tool to aid screening. Adult patients with influenza or severe acute respiratory syndrome (SARS), some of whom may also have received treatment for Covid-19, were in the emergency department of São Paulo University Hospital. 136 patient samples were collected and examined in the emergency room of the said hospital from June to September 2022 according to inclusion and exclusion criteria, in which temperatures of 10 parameters were captured from different regions of the face. The results showed that the predictive model reached an accuracy of 86% for detecting diseases.

- BRIOSCHI et al. 2023 [21] a model that uses thermography to screen people with fever or elevated temperatures created to meet the needs of society and create a new, fast and effective way to detect infectious Covid-19. A new thermography-based approach has been developed for potential early detection of Covid-19 infection in infected or uninfected people. A practical algorithm for wider use of the technique was then created using 1,206 emergency department patients as samples. Then out of 227,261 samples, 2,558 cases analyzed workers in five different countries to assess the effectiveness of the strategy and algorithm. An artificial intelligence called a convolutional neural network was used to build an algorithm that uses thermal images of patients' faces as input. The risk is rated low or medium risk and low temperature. The results showed that suspected and confirmed cases of COVID-19 (+) characterized by temperatures below the fever threshold of 37.5°C were identified. Also, mean forehead and eye temperatures over 37.5°C were not sufficient to detect fever similarly to the proposed CNN algorithm. Most of the RT-qPCR confirmed cases are COVID-19(+) cases found in the sample of 2558 cases (17 cases/89.5%) belonging to a selected subset of CNN.
- Singh et al. 2023 [22] the system done can have the ability to scan a person's temperature and analyze the measured temperature simultaneously with the recorded/stored information/data presented in this paper. The system done is also capable of sending an email notification to the relevant authorities during the analysis process in real time. In addition, this information was also recorded in the system database for continuous monitoring of the health status of the person concerned. The system development that was done was integrated with the AMG8833 thermal

module, Pi camera and Raspberry Pi Zero Wireless. The system was tested and the results achieved met the development goals.

1.□ □ro□le□ □tate□ent

The problem statement for extracting human temperature using thermal imaging revolves around the need for a biometric system or an accurate and effective method for measuring body temperature in different locations. Conventional methods of measuring temperature, such as contact-based thermometers, can be invasive, time-consuming, and error-prone. Furthermore, in scenarios where a large number of individuals need to be screened quickly, such as during a pandemic or in high traffic areas, manual temperature checks become impractical. The complexity arises from factors such as differences in ambient temperature, clothing, distance, and different anatomical regions exhibiting varying temperatures. Moreover, accurately locating the face region in thermal images and removing interference from environmental heat sources present additional obstacles.

1.□ □i□ o□the □hesis

This thesis aims to contribute to the development of an effective and accurate bioinformatic system for detecting human body temperature using machine learning techniques. With the growing need for non-invasive and automated temperature inspection in various environments, such as airports, hospitals, and public places, the goal is to leverage K-Means and CNN machine learning algorithms to analyze thermal data and accurately identify abnormal body temperatures. By training the model on a variety of thermal image data and incorporating features such as facial temperature distribution, the thesis aims to improve the performance of the temperature detection system, ensuring reliable results and aiding in early detection of potential health risks.

1.□ Outline o□the □hesis

The other chapters in this thesis are as follows:

- **Chapter □□o□**theoretical background that outlines and discusses the primary background theories that are used in studies as well as the primary tools, methods, and techniques for digital image processing as well as basic essentials.
- **Chapter □hree□**design and implementation of the proposed system, which outline and discuss the proposed system's overall methodology and each stage that has been implemented. Additionally, some of the algorithms, pseudocode, and flowcharts utilized in the suggested system have been detailed.
- **Chapter □our□**experimental results that summaries and describe the key outcomes obtained in the suggested system using various metrics, including figures, tables, and graphs.
- **Chapter □i□e□**conclusion and recommendations for upcoming works. we conclude by listing some findings from our study as well as some recommendations for future work.

الخلاصة

ارتفاع درجة حرارة الشخص فوق المستوى الطبيعي يعتبر حالة مرضية ، أو أنه كان مريضًا لفترة طويلة ، أو من الإجهاد أو عوامل كثيرة ، وفقًا لمنظمة الصحة العالمية ، ووفقًا لأطباء متخصصين. في الآونة الأخيرة ، كانت هناك حاجة كاملة لقياسات درجة الحرارة عن بعد وتجنب الاتصال ، حيث تم استخدام مسدس قياس درجة الحرارة كأحد الحلول الحالية ، لكن العالم شهد زيادة في عدد الإصابات بـ COVID-19 لأن المسدس الحراري يجب أن يقترب من على مسافة تقل عن نصف متر لقياس درجة حرارته بدقة وأن الموظف المسؤول على استخدام مسدس حراري تبين أنه مصاب بعد فترة بسبب المسافة القريبة بينه وبين المريض. هنا ظهرت حاجة العالم لمقياس درجة الحرارة عن بعد ، وبعض الشركات تنتج كاميرات حرارية لكنها لا تعرض درجة حرارة الجسم بل تعطي صورة حرارية لكل ما يتم تصويره. توجد مشكلة في معايرة والفيديوهات الملونة والحرارية وايضاً استخراج الحراري للوجه. يقترح إنشاء نموذجين لقياس درجة حرارة الإنسان من خلال الوجه فقط. في هذه الأطروحة ، تم استخدام قاعدة بيانات (الوجوه الناطقة) ، وتم إنشاء النموذج الأول للكشف عن درجات حرارة بشرة الوجه الحرارية دون إشراف. لتحقيق المطابقة ، تم استخدام أربعة أنواع من طرق الريجيستريشن ، ثم تم استخدام خوارزمية K-mean للكشف عن الوجه على الصورة الملونة. تم بناء النموذج الثاني الخاضع للإشراف لاستخراج أقنعة الوجه على أساس التجزئة الدلالية العميقة. تم حل مشاكل التكلفة المالية من خلال النموذج الثاني الذي نقوم به بدون الكاميرات الملونة تمامًا كما نفعل بدون الكاميرات الحرارية باهظة الثمن. أظهر النموذج الأول نتائج (78٪) ، بينما أظهر النموذج الثاني نتائج (95.72٪).