Detection of a Human Body and object Sanitization using Deep Neural networks with Thermal Imaging

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Abstract:
Thermography, or thermal visualization is a type of infrared visualization. Thermographic cameras are used in many heavy factories like metal recycling factories, wafer production factories and etc for monitoring the temperature conditions of the machines. Besides, thermographic camera can be used to detect trespassers in environment with poor lighting condition, whereby, the conventional digital cameras are less applicable in.Recent statistics indicate that the number of people diagnosed with COVID-19 is increasing exponentially, with more than 1.6 million confirmed cases; the disease is spreading to many countries across the world.In this paper, we proposed simple and fast detection algorithms into a cost effective detection of a body sanitized or not using thermal imaging.this model is used for detecting whether a person is fully sanitized or not it can also be used for the different products too .Experimental results show that the proposed model achieves high accuracy in monitoring persons heat and detecting whether sanitized or not.

Keywords- Coronavirus (COVID-19), Deep learning,Thermal imaging system, Body heat monitoring, sanitization detection, Image Processing & Understanding.

1. Introduction

COVID-19 presentation, which began with the reporting of unknown causes of pneumonia in Wuhan, Hubei province of China on December 31, 2019, has rapidly become a pandemic [1-3]. The disease is named COVID-19 and the virus is termed SARS-CoV-2. This new virus spread from Wuhan to much of China in 30 days [4]. The United States of America [5], where the first seven cases were reported on January 20, 2020, reached over 300,000 by the 5th of April 2020. Most coronaviruses affect animals, but they can also be transmitted to humans because of their zoonotic nature. Severe acute respiratory syndrome Coronavirus (SARS-CoV) and the Middle East respiratory syndrome Coronavirus (MERS-CoV) have caused severe respiratory disease and death in humans [6]. The typical clinical features of COVID-19 include fever, cough, sore throat,headache, fatigue, muscle pain, and shortness of breath [7].

To date, there have been no detailed studies on the potential of artificial intelligence (AI) to detect COVID-19 automatically.so the best practice is to avoid it as much as possible and it can be done by getting in less contact with the people around, wearing masks and sanitization.

The coronavirus is very much easily transmissible and can stay upto days/hours in different objects like stainless steel,cardboard,clothes and many different products and can only be removed by proper sanitization,at recent times there are a lot of machines which helps for proper sanitization but nothing to detect whether a person or an object is fully sanitized or not. if we can detect whether an object is fully sanitized or not after sanitization can help to destroy the chain of transmission of this deadly virus.

Deep learning,which is a popular research area of artificial intelligence (AI), enables the creation of end-to-end models to achieve promised results using input data, without the need for manual feature extraction [8,9] . Deep learning techniques have been successfully applied in many problems such as arrhythmia detection [10,11], skin cancer classification[12,13] , breast cancer detection [14,15], brain disease classification[16] , pneumonia detection f-rom chest X-ray images[17], fundus image segmentation[18], and lung segmentation[19,20]. The COVID-19 epidemic's rapid rise has necessitated the need for expertise in this field. This has increased interest in developing the automated detection systems based on AI techniques. It is a challenging task to provide expert clinicians to every hospital due to the limited number of radiologists. Therefore, simple, accurate, and fast AI models may be helpful to overcome this problem and provide timely assistance to patients. Although radiologists play a key role due to their vast experience in this field, the AI technologies in radiology can be assistive to obtain accurate diagnosis [21]

In this paper,simple and fast detection are embedded into a cost effective thermal imaging stanitization detection system.this system not only can be used on the humans also on the objects to detect whether properly sanitized or not.it can be used to check whether the whole object is sanitized by detecting every point of the object on the same site.it can be used in a poor lightning condition and can achieve a high accuracy in detection of sanitized part.The paper is organized in the following way: Section II will be briefly comments on the thermal imaging sanitization detection system. Section III presents the proposed algorithms for Detection of a human Body and object Sanitization using Deep Neural networks with Thermal Imaging, section IV reports some experimental results. Finally in section V, we draw some conclusions and envision future developments.

2. Thermal imaging for sanitization detection model

2.1 Model Description :

In this paper, we will take images from the thermal camera after the sanitization of the body and process that image with an CNN algorithm for the identification of human body and different objects whether they are properly sanitized or not and if it is partially sanitized then an alarm rings for the identification .as a average temperature of human body varies from 97.7–99.5 °F and in thermal imaging it shows yellow-orange color and after the sanitization the image shows blue-purple color.as in fig 2.1 it shows a human arm before sanitization and after sanitization.

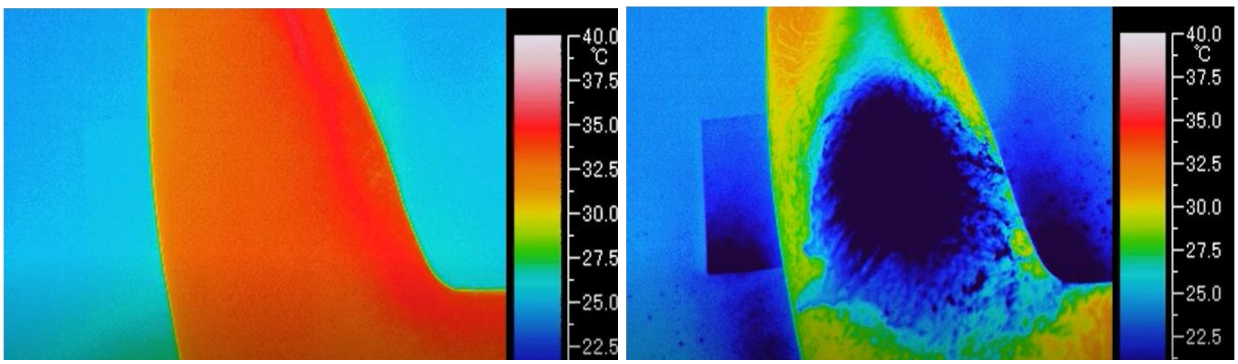

Fig 2.1 A human arm before sanitization and after sanitization

The Thermal imaging for sanitization detection model proposed in this paper is shown in Fig.2.2 The system is very simple, it requires a fine resolution thermal camera and a laptop/PC where we can run deep neural networks for image classification.

Fig2.2 Thermal imaging for sanitization detection model

Thermal Camera :

A thermal camera captures and creates an image of an object by using infrared radiation emitted from the object in a process that is called thermal imaging. The created image represents the temperature of the object. The underlying technology of the thermal imaging cameras was first developed for the military. However, the invention of the thermal camera is related to the history of thermography which began in 1960 by Sir William Herschel, an astronaut who discovered infrared light.Thermal imaging is all about converting that infrared light into electric signals and creating an image using that information.The common standard today for thermal camera is showing warmer, objects with a yellow-orange hue that gets brighter as the object gets hotter. Colder objects are displayed with a blue or purple color.Infrared energy has a wavelength starting at approximately 700 nanometers and extends to approximately 1mm. Wavelengths shorter than this begin to be visible by the naked eye. Thermal imaging cameras use this infrared energy to create thermal images. The lens of the camera focuses the infrared energy onto a set of detectors that then create a detailed pattern called thermogram. The thermogram is then converted to electrical signals to create a thermal image that we can see and interpret.the laptop/pc which is connected to the thermal camera then processes the images captured by thermal camera.

Laptop/PC :

A laptop or PC can be used for image processing and classification , either placed on site or in a monitoring room.CNNs are used for image classification and recognition because of its high accuracy. The CNN follows a hierarchical model which works on building a network, like a funnel, and finally gives out a fully-connected layer where all the neurons are connected to each other and the output is processed. It can partition the images captured by the thermal camera easily according to each single person or object to be monitored, process captured thermal images smoothly with the algorithm we programmed in and an alarm operator which will make some sound to identify whether the object is sanitized or not.

3. Algorithm for Detection of a human Body and object Sanitization using Deep Neural networks with Thermal Imaging

In this paper, we propose simple and effective algorithms for Detection of a human Body and object Sanitization using Deep Neural networks with Thermal Imaging.

3.1 Convolutional Neural Network for Image Classification :

Artificial Neural Networks are made of artificial neurons inspired by biological neurons present in our brain. Convolutional Neural Network (CNN) is a modified variant of feed-forward neural network which is generally used for image classification tasks. CNNs can recognize a particular object even when it appears in different ways, as it understands translation invariance. This is a key point which makes CNN advantageous over feed-forward neural networks which cannot understand translation invariance.

In layman words, feed-forward neural networks only recognize an object when it is right in the center of the image, but fails notably when the object is slightly off position or placed elsewhere in the image. Basically, the network understands/learns only one pattern. This is precisely not convenient as the real world datasets are usually raw and unprocessed.

3.2 Working of Convolution Neural Networks

The question which arises here is how does CNN understand translation invariance? Is it the magic of Machine Learning? Yet again, it comes down to mathematics again. The following operations are the various layers/steps of the CNN:

•Convolution
•Pooling
•Flattening
•Full Connection

We will now see what happens in each step in detail

3.2.1 Convolution

The first operation, Convolution, extracts important features from the image. It is a mathematical operation which clearly requires two inputs, an image matrix and a filter or kernel. The filter is traversed through the image and multiplied with the pixel values to obtain a feature map.
Fig 3 shows how the convolution operation happens.

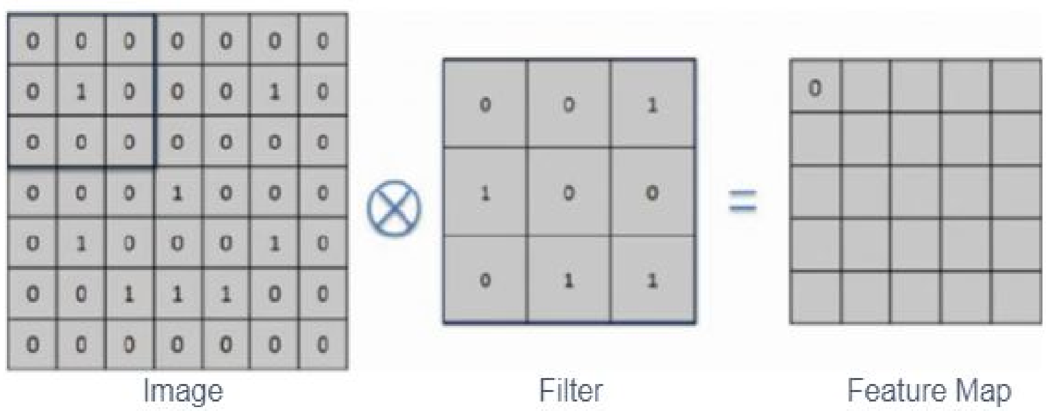

Fig 3 convolutional operation

Convolution does lose information, but the point here is to reduce size and learn the integral information. Performing convolution with different kinds of filters can assist in image sharpening, edge detection, blurring and other image processing operations.

3.2.2 Pooling

Pooling operation helps in decreasing the number of parameters when the image is very large in size. Subsampling also called Spatial Pooling curtails the dimensionality of each feature map but retains significant information.

Pooling is of basically divided into three types:
•Max Pooling (mostly used)
•Sum Pooling
•Average Pooling
Max pooling is a sample-based discretization process. It is done by applying a N×N max filter over the image, which selects the highest pixel value in each stride and builds the feature map. Similarly, in average and sum pooling, the average and sum of pixel values are taken into the feature map.
Fig 4 depicts the Max Pooling operation.

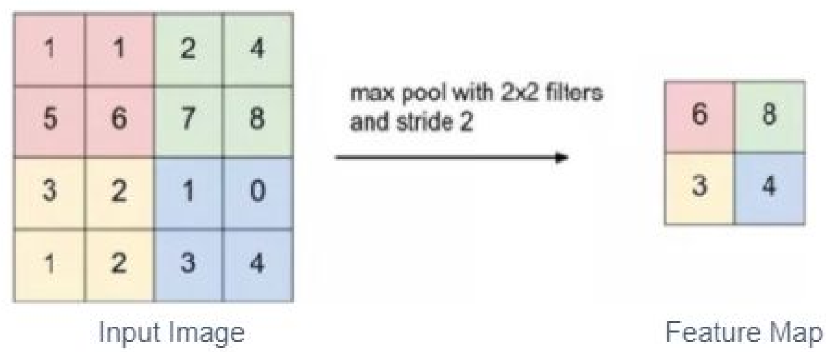

Fig 4 max pooling

3.2.3 Flattening

To feed our feature maps in to the artificial neural network, we need a single column vector of the image pixels. As the name suggests, we flatten our feature maps into column like vector.
Fig 5 depicts the flattening process.

Fig 5 flattening process

3.2.4 Full Connection

The fully connection layer takes the input from the preceding convolution/pooling layer and produces an N dimensional vector where N is the number of classes to be classified. Thus, the layer determines the features most correlating to a particular class based on the probabilities of the neurons.
Fig 6 shows the fully connected layer in a neural network.

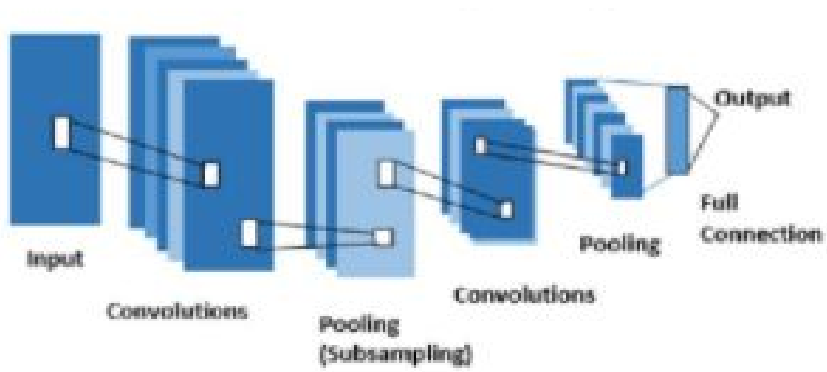

Fig6 Fully Connected layers

3.3.1 Flow chart for the model :

The following flow chart is used in this system:

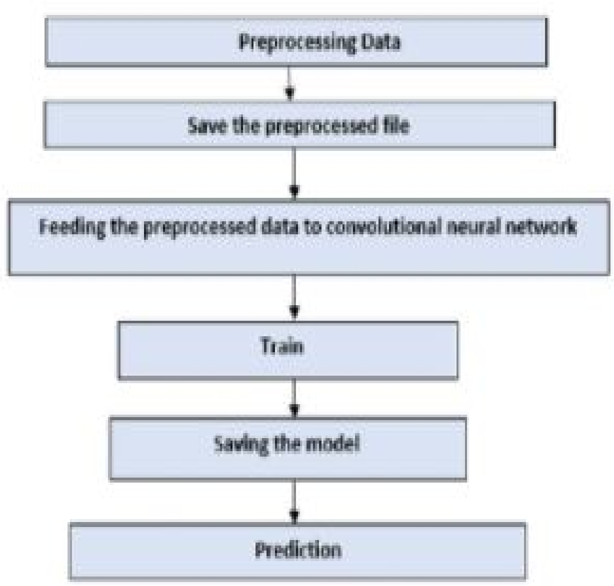

Fig 7 flow chart of model

3.3.2 Steps of the system
The following steps are used to detect whether the given image is sanitized or not-
•Step1 : Initializing all the images and all the parameters that are needed for the system.
•Step2: The system takes a training image as input and saves the images into the system.
•Step3:The system uses convolutional neural network and finds out the prediction
•Step4: Training with the convolutional neural network that is generated in step 3.
•Step5: Save the model into the system for prediction of the test data.
•Step6: Evaluate the result with the standard evaluation metrics like accuracy, precision, recall, and f1 score.

3.3.3 Step wise explanation of algorithm of model

The stepwise explanation of algorithm of model:
Step 1 : Preprocessing data. In compute vision, one of the main obstacles is the huge size of the images. The input data can be very big. The input feature dimension can be 14700 if the inputted image is 70×70×3. Suppose the image size is 1024×1024×3then the feature size will be huge for computation to pass it to a deep neural network specially convolutional neural network (depending on the number of hidden units). There are three channels of images. The three channels are RGB (Red, Green, Blue). Because of the lack of computational capacity, we need to attempt to characterize a solitary channel when we read the picture. Another issue is the span of the picture. The data set contains pictures that are exceptionally huge in width and height. The width of the picture is 1022 and the height of the picture is 767 which is extremely substantial to process and needs considerably more computational capacity to register several pictures which is very time consuming and a waste of memory. Along these lines, we need to resize the information pictures so our machine can process the pictures with less memory and graphical computational power. To tackle these two problems while reading the images, it will be denied such a way that only one color channel remains. For our cases, gray scale images are generated from original images that is easier for CPU to process.Fig 8 shows thermal image of a person and a person with a dog.

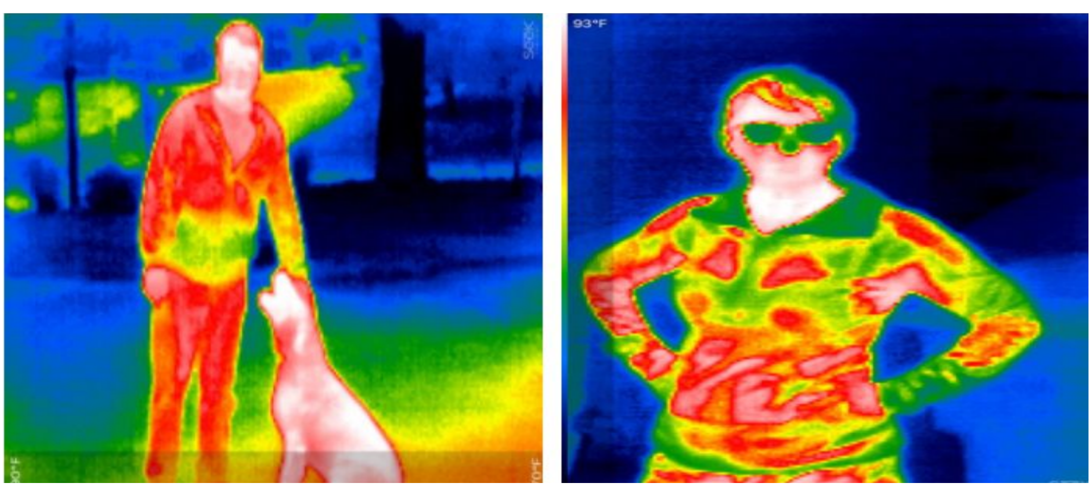

Fig 8 thermal image of a person and a person with a dog.

Step 2:Save the preprocessed file. Each of the preprocessed images are saved in the record along with their classes. From the dataset, sanitized and not sanitized images are taken for further processing. We have to discard the images that do not have any class label.Finally, the recorded images are used to feed to a convolutional Neural Network.

Fig 9 shows image after sanitization.

Fig 9 image after sanitization.

Step 3:Feeding the preprocessed data to a convolutional neural network (CNN). Three types of layers are present in a convolutional Neural Network. That are given in following part:
•Convolution layer
•Pooling layer
•Fully connected layer
Convolution Layer: By using an example, our system is described here. Suppose we have a 6×6gray-scale image (i.e. only one channel) as gure 3. Again, We have 3×3lter.Firstly, 3×3matrix were taken from the 6×6image and accumulate the lter with it. As a result, the sum of the element-wise product of these values equals to the rst element of 4×4output, for examples 5×1+0+2×−1+3×1+5×0+8×−1+2×1+5×0+6×−1=−6.The second element of 4×4 output were calculated again by the sum of the element-wise product via shifting the lter one unit at the right. Similarly, the entire image were convoluted to produce a 4×4output as gure 6.In general, it can be stated as convolving an input of x×x with a y×y filter will results in (x−y+1)×(x−y+1).

$$
\begin{bmatrix} 5 & 3 & 2 & 1 & 7 & 4 \\ 3 & 5 & 8 & 9 & 1 & 3 \\ 2 & 5 & 6 & 0 & 1 & 4 \\ 1 & 6 & 7 & 1 & 0 & 2 \\ 6 & 2 & 4 & 0 & 8 & 2 \\ 2 & 5 & 4 & 2 & 3 & 9 \end{bmatrix} * \begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix}
$$

Fig 10. 6 x 6 image with 3 x 3 filter

$$
\begin{bmatrix} -6 & 3 & 7 & -1 \\ -15 & 6 & 19 & 1 \\ -8 & 12 & 8 & -7 \\ -6 & 10 & 4 & -10 \end{bmatrix}
$$

Fig 11. 4×4 image after applying 3 × 3 filter to 6 × 6 image

•Input:x×x
•Filter size:y×y
•Output:(x−y+1)×(x−y+1)
One major disadvantage of the convolution operation is the shrinkage of the size of the image. Compare to the pixel at the center of an image, the pixels at the corner are utilized only a few number of times to overcome the information loss. It has been done by padding the image by adding an extra border (i.e. adding one pixel all around the edges) which makes the input of size an 8 × 8 matrix (instead of a 6 × 6 matrix). Now, convolution of 8 ×8 input with a filter of size 3×3 matrix will result the original image of a size of 6×6 matrix which can be generalized as:
•Input:x×x
•Padding:p
•Filter size:y×y
•Output:(x+2p−y+1)×(x+2p−y+1)
To reduce the image size stride is an important and useful feature in CNN. For example, convoluting the image via choosing a stride of 2 will take both vertical and horizontal directions separately. The dimensions for stride scan be stated as:
•Input:x×x
•Padding:p
•Stride:z
•Filter size:y×y

•Output:[(x+2p−y)/z+1] × [(x+2p−y)/z+1]
So after adding the bias the equation will look like 1. Then it is passed to the rectified linear unit activation function 2. Here B*i* Is the biased terms. xiis the input image and wiis the lter.
zi+ = b*i*+xi×wi
Relu (zi)=max(0,zi)

Pooling Layers: To reduce the image size and increase the computation speed, pooling layers are typically used. Consider a 4 × 4 matrix as shown below:

-6	3	7	-1
-15	6	19	1
-8	12	8	-7
-6	10	4	-10

Fig12. Images for pooling layers

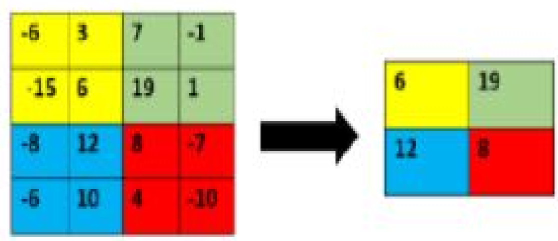

Fig 13. Result after applying max pooling.

For every consecutive 2 × 2 block, the maximum number was taken and 2 unit sizes of both lter and stride were applied. If the input of the pooling layer is $x_h \times x_w \times x_c$, the output will be [{(x_h−y)/z+1}×{x_w−y)/z+1} × x_c]. Then, We again apply convolutions and pulling for extract more complex features. The features are atten to a single layer so that we can feed the model to a fully connected neural network. Then after applying the softmax, the desired result that is sanitized or not sanitized is found.

$$Output = \frac{Z_i}{\sum_{i=1}^{n} (Z_{i,k})}$$

Step 4 : Train. We have to train our model up to 150 times. Every time the loss of the system decreases to a certain level.While training epochs is approximately 140, then we didn't notice any significant amount of change in loss. So, we have to stop our iteration at 150.

Step 5 : Saving the model. Model is saved for further testing purposes. The model is then used to predict the images that might Contain sanitized or not sanitized images.

Step 6 : Prediction. We have to predict the images using the final output layer. After the prediction of the testing images, we evaluate our system with the accuracy, precision, recall and f1 score measures.

3.4 Evaluation Metrics:

It is to access the reliability of the proposed model.These matrices are calculated on the basis of True-Positive(TP),True-negative(TN),False-positive(FP) and False-negative(FN) scores :

Accuracy: This metric measures the percentage of correctly identified cases relative to entire dataset. The ML algorithm performs better if the accuracy is higher.accuracy is a significant measure for a test dataset that includes a balanced class. It computed as follows:

Accuracy = (TP+TN)/(TP+TN+FP+FN)

Precision : The metric is a measure of exactness , which is calculated as the percentage of positive prediction of a body sanitized that were true positives divided by the number of predicted positives. It is computed as

Precision = TP/(TP+FP)

Recall : this metric is a measure of completeness which is calculated as th percentage of positives that were correctly identified as true positives divided by the number of actual positives. It is computed as follows :

Recall = TP/(TP+FN)

F-measure: this ia a combination of precision and recall that provides a significant measures for a test dataset that includes an imbalance class it is computed as follows :

F-measures: 2*{(precision * recall) / (precision + recall)}

4.Experimental Results and discussion

In this Section ,we briefly explain illustrate of the proposed Detection of a Human Body and object Sanitization using Deep Neural networks with Thermal Imaging model for the human sanitization detection part we take the thermal image of the person just after the sanitization if the person is properly sanitized then he/she is allowed to move forward but if the person is not properly sanitized or partially sanitized an alarm sound can be generated.for the object part same as above we will take the thermal images just after sanitization process and check in neural network if the object is sanitized or not sanitized.for implementing this model in factories or some other places we can just take a lot of images divide it into sanitized and not sanitized object and then train the model and get an high accuracy.

Some places where we can use this model are:
As we know there are lot of places where there is a lot of people come and go and a human eye cannot check whether a person is fully sanitized or not as the person can be a corona carrier so this model can be used there to check whether the person is sensitized and if not then an alarm can be placed or a person can check on the pc/laptop to identify the person.
Same as above in many factories where the product is handmade there sensitization of the product is very much necessary so getting thermal images just after sanitization can check whether the product is fully sanitized or not sanitized.

5. Conclusion

In this paper, a Convolutional Neural Networks based approach has been proposed for detection of a human body or object sanitized or not sanitized.A system is developed to help the people to get aware that they are sanitized and help to break a coronavirus chain. The best practice and currently the only way to get rid of covid-19 is to not let it spread and it can only be done by taking high precautions. By taking some random images anyone can detect wether an object or a human body is sanitized or not sanitized.

References :

[1] Wu, F., Zhao, S., Yu, B., et al. (2020). A new coronavirus associated with human respiratory disease inChina. Nature, 579(7798), 265-269.
[2] Huang, C., Wang, Y., et al. (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. The Lancet, 395(10223), 497-506.
[3] World Health Organization. (2020). Pneumonia of unknown cause–China. Emergencies preparedness, response, Disease outbreak news, World Health Organization (WHO).
[4] Wu, Z., McGoogan, J. M. (2020). Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. Jama.
[5] Holshue, M. L., DeBolt, C., et al. (2020). First case of 2019 novel coronavirus in the United States. New England Journal of Medicine.
[6] Kong, W., & Agarwal, P. P. (2020). Chest imaging appearance of COVID-19 infection. Radiology:Cardiothoracic Imaging, 2(1), e200028.
[7] Singhal, T. (2020). A Review of Coronavirus Disease-2019 (COVID-19). The Indian Journal of Pediatrics, 1-6.
[8]LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. nature, 521(7553), 436-444.
[9] Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). Imagenet classification with deep convolutional neural networks. In Advances in neural information processing systems (pp. 1097-1105).
[10] Yıldırım, Ö., Pławiak, P., Tan, R. S., & Acharya, U. R. (2018). Arrhythmia detection using deep convolutional neural network with long duration ECG signals. Computers in biology and medicine, 102, 411-420.
[11] Hannun, A. Y., Rajpurkar, P., Haghpanahi, M., Tison, G. H., Bourn, C., Turakhia, M. P., & Ng, A. Y. (2019). Cardiologist-level arrhythmia detection and classification in ambulatory electrocardiograms using a deep neural network. Nature medicine, 25(1), 65.
[12] Acharya, U. R., Oh, S. L., Hagiwara, Y., Tan, J. H., Adam, M., Gertych, A., & San Tan, R. (2017). A deep convolutional neural network model to classify heartbeats. Computers in biology and medicine, 89, 389-396.
[13] Esteva A, Kuprel B, Novoa RA, et al. Dermatologist-level classification of skin cancer with deep neural networks. Nature. 2017;542(7639):115-118. doi:10.1038/nature21056.
[14] Codella, N. C., Nguyen, Q. B., Pankanti, S., Gutman, D. A., Helba, B., Halpern, A. C., & Smith, J. R. (2017). Deep learning ensembles for melanoma recognition in dermoscopy images. IBM Journal of Research and Development, 61(4/5), 5-1.
[15] Celik, Y., Talo, M., Yildirim, O., Karabatak, M., & Acharya, U. R. (2020). Automated Invasive Ductal Carcinoma Detection Based Using Deep Transfer Learning with Whole-Slide Images. Pattern Recognition Letters.
[16] Cruz-Roa, A., Basavanhally, A., et al. (2014, March). Automatic detection of invasive ductal carcinoma in whole slide images with convolutional neural networks. In Medical Imaging 2014: Digital Pathology (Vol. 9041, p. 904103). International Society for Optics and Photonics.
[17] Talo, M., Yildirim, O., Baloglu, U. B., Aydin, G., & Acharya, U. R. (2019). Convolutional neural networks for multi-class brain disease detection using MRI images. Computerized Medical Imaging and Graphics, 78, 101673.

[18] Rajpurkar, P., Irvin, J., et al. (2017). Chexnet: Radiologist-level pneumonia detection on chest x-rays with deep learning. arXiv preprint arXiv:1711.05225.
[19] Tan, J. H., Fujita, H., Sivaprasad, S., Bhandary, S. V., Rao, A. K., Chua, K. C., & Acharya, U. R. (2017). Automated segmentation of exudates, haemorrhages, microaneurysms using single convolutional neural network. Information sciences, 420, 66-76.
[20] Gaál, G., Maga, B., & Lukács, A. (2020). Attention U-Net Based Adversarial Architectures for Chest X-ray Lung Segmentation. arXiv preprint arXiv:2003.10304.
[21] Souza, J. C., Diniz, J. O. B., Ferreira, J. L., da Silva, G. L. F., Silva, A. C., & de Paiva, A. C. (2019).An automatic method for lung segmentation and reconstruction in chest X-ray using deep neural networks. Computer methods and programs in biomedicine, 177, 285-296.
[22] Caobelli, F. (2020). Artificial intelligence in medical imaging: Game over for radiologists?. European journal of radiology, 126, 108940.