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IoT Enabled Stress Detection Based on Image Processing with Ensembling Machine Learning Approach

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Abstract: Once a product, or more particularly, a central processing unit system, has been constructed, the objective of this article is to automate the quality control process in order to make it more effective than it now is. In order to facilitate quality control, improve productivity, and accelerate the production process, it is essential to develop a model that automatically rejects anomalous goods. This will help reduce the number of defective products. Image processing, which relies on the use of specialised cameras or imaging systems positioned inside the production line, is one of the most common techniques for accomplishing this objective and has become one of the most popular approaches in recent years. In this piece, we provide a method that is both very effective and highly productive for automating the production lines of central processing units in a particular industry. This method may be found in this article. The model analyses photographs of the manufacturing lines, searches for deviations in the way their components are put together, and then summarises the findings. After that, this information is sent through a network that is part of a cyber-physical cloud system to the administrator of the system.

Keywords: *Image Processing, Machine Learning, Internet of Things.*

1. Introduction

The incorporation of renewable energy sources such as In the course of the previous several decades, our reliance on the conveniences of modern life has significantly increased. The way in which humans engage with information technology (IT), on the other hand, is critically important in a great number of contexts. Because of our reliance on a wide variety of technology, the way in which we communicate and engage with the rest of the world has undergone tremendous transformation in recent years. In the past, individual computer systems were not at all connected to one another in any way. However, in today's world, they are constructed with the express purpose of connecting with one another and with humans. The individual parts of a gadget may be connected through a network in order to carry out a diverse range of tasks, which is exactly what is happening all over the place right now. The vast majority of these devices are equipped with sensors that not only collect data but also make it possible for different devices to connect with one another. After then, the information might be made accessible to other people and other devices in line with the requirements of those parties. The quality control system that we recommend in this article is based on image processing, and the several pieces of hardware that are necessary for it to function are all linked to one another via a cyber-physical cloud system (CPCS) [1].

The manufacture of goods in large quantities is an activity that many industries often engage in. Issues with efficiency, prices, and the duration of the production run are only some of the obstacles that might occur when mass manufacturing is involved. In recent years, a number of different industries have started looking to automation as a potential answer to these problems. It is essential to have a process that inspects the final products for any flaws at the very end of the production line in order to maintain the high quality of the items that are being produced. The majority of different industries have begun using automated systems that make use of image processing in order to address the problems that were previously brought to light. It is impossible for automated production

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processes to function properly in the absence of an image processing system. The widespread availability of high-performance digital cameras and communication interfaces on the market has led to significant improvements in the efficacy and speed of image processing. These improvements have been made in recent years. The amount of money spent on processing photographs has gone down, and the overall quality of the programme has been improved [2].

Nonetheless, atomizing the industrial process comes with its own unique challenges to overcome. Both the performance of the central processing unit (CPU) and the ability to organise one's time effectively have become more important. The quality assurance and control processes are given the utmost priority in the manufacturing procedure. Throughout the whole production process, machines that are capable of making efficient use of computer vision are required to make component identification feasible.

Over the course of the last several years, industrial vision systems have already been the focus of a significant amount of research and investigation. The machine vision inspection systems that are used in companies now are more reliable and efficient than the machine vision inspection systems that were used in businesses in the past. These many methods of inspection are used. Researchers are working to build industrial vision systems that are speedier, more inexpensive, and more effective than those already available. In addition to checking the operational quality, it is possible to use industrial vision systems to inspect the structural quality, surface quality, and dimension quality of the product. Now, depending on the categorisation, the procedures or approaches that were used in the course of the examination may have been different from one another. The primary concentration of this paper will be on the structural quality, which can also be referred to as the correct assembly of the various parts. Initially, while the CNN approach was being developed, it was believed to be the most effective method for recognising mathematical patterns or English words. According to the findings of a large number of studies, there are a variety of approaches to training and evaluating CNNs that may improve their performance [3].

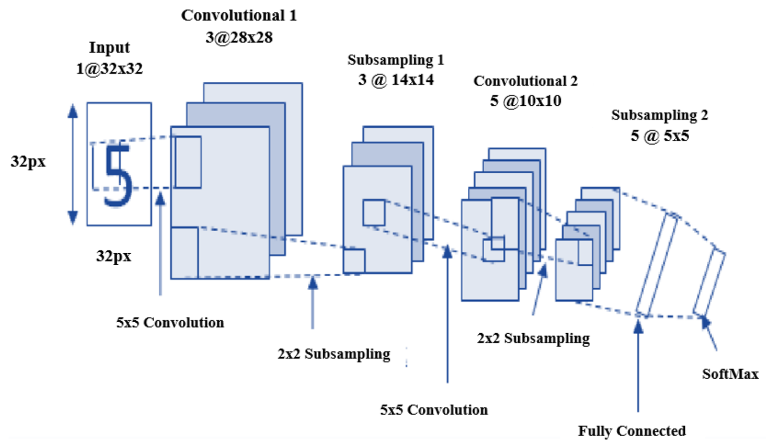

Fig 1: Architecture Of Cnn

An enhanced model of the artificial neural network architecture known as the multilayer perceptron (MLP) was the basis for the development of convolutional neural networks (CNN). The meaning of the abbreviation CNN is "convolutional neural networks." CNN, on the other hand, is constructed using a convolutional layer in addition to a subsampling layer, in contrast to MLP. The implementation of the following three distinct types of machine learning has been granted the green light by CNN: Almost Always Only a Very Slight Participation 2. How Members of the Community Make Use of Parameters It is equivariant in terms of the representation that it takes. In sparse interaction, the kernel is shortened till it is smaller than the input in order to separate minor and large features like edges. This is done so that the kernel can differentiate between the two. One example of these characteristics is the presence of ridges and corners. In certain contexts, it may also be referred to as the sparse weight or the sparse connectivity. The technique of applying the same weights to all feature maps, which results in a reduction in the total number of parameters, is referred to as "parameter sharing," which is also the name of the method. As a consequence of the layer's parameters being shared, it has the equivariance property as well as the translation property. Each layer is connected to the one that came before it via the use of a filter [4].

2. Review of Literature

Once a product, or more particularly, a central processing unit system, has been constructed, the objective of this article is to automate the quality control process in order to make it more effective than it now is. In order to facilitate quality control, improve productivity, and accelerate the production process, it is essential to develop a model that automatically rejects anomalous goods. This will help reduce the number of defective products. Industrial image processing is a method that is often used for the purpose of achieving this objective. The foundation of this tactic is the use of sophisticated cameras or imaging systems that are built into the production line itself. In this piece, we provide a method that is both very effective and highly productive for automating the production lines of central processing units in a particular industry. This method may be found in this article. The model analyses photographs of the manufacturing lines, searches for deviations in the way their components are put together, and then summarises the findings. After that, this information is sent through a network that is part of a cyber-physical cloud system to the administrator of the system. A approach that is based on machine learning is used in this context to assure accurate categorisation. According to the techniques that we employ, this model, which focuses on flaws but also helps define the angles from which images of the production are taken, has an accuracy of 92% [5].

This article creates a model of an autonomous vehicle on a smaller scale by making use of the Internet of Things. An 8MP pi high-resolution camera will provide the necessary information, the data will be analysed by the raspberry pi, and the raspberry pi will be educated in pi using neural networks and a machine learning method. As a consequence of this, the raspberry pi will be able to recognise things like traffic lanes and lights, as well as other aspects of a similar kind, and the automobile will respond appropriately. Both the Adriano UNO and the Raspberry Pi will function as the primary CPUs in this arrangement. In addition to these features, an appropriate LED signal will light up and activate when the vehicle has successfully navigated around any obstacles [6].

The mathematical treatment of anomaly and the method required to identify it are the primary focuses of this work. The use of mathematical symbols and equations that are formulated by hand has garnered a significant amount of attention in the area of pattern recognition. The creation of brand new and more sophisticated algorithms for the identification of handwritten characters has led to the compilation of a data set of handwritten digits that encompasses a greater variety of characteristics. For the purpose of recognising handwritten characters, several mathematical formulae were developed. However, in the end, the problem may be traced back to the way in which the handwritten data sets behave. We offer a more complicated handwritten digit representation model based on multiple instance learning (MIL), in which a bag incorporates several digit data from different feature spaces, in order to circumvent the constraint that a handwritten digit data set of independent features is unable to compute. In this model, a handwritten digit is represented as a bag of digits. In this method, the various digit values are gathered together and stored in a bag. This article presents a wide variety of offline pattern detection tactics by making use of a number of different machine learning approaches. Among the numerous different types of machine learning strategies that are now accessible, a few examples are multilayer perception, convolutional neural networks, and support vector machines. The primary objective or target is to identify the method of pattern recognition that is capable of producing the best results while using the fewest resources possible. The research reveals how different methods of categorisation provide findings that vary in degrees of accuracy to varying degrees. The process of identifying letters and numbers often makes use of methods that are associated with machine learning. Performing an initial, "rough" categorization of a segment binary picture is the first step that the Bayesian Network does before moving on to the classifications that are more precise. Utilising neural networks to assist in the process of content categorization is another viable option [7].

These apps adhere to industry standards when it comes to the sensors and protocols that they employ. The idea of machine-to-machine communication (M2M), which is essential to the Internet of Things (IoT), will be covered in this article, along with typical networking protocols and the applications for each of them. This study also presents an Internet of Things operation that makes use of a processing system that includes a camera for the purpose of taking photographs and Xilinx system generator (XSG)models for the purpose of constructing the system [8].

3. IoT Based Image Processing

In order for the Internet of Things (IoT) to become a reality as a fully integrated future Internet, it is essential that it include all of the necessary technological components. It will be discussed in even greater depth. Technology that makes things easier is essential in today's culture. The objective of this activity is to provide a concise explanation of the roles that are played by each component within the context of the IoT paradigm. The core component of the Internet of Things is shown in Figure 2, which may be seen below.

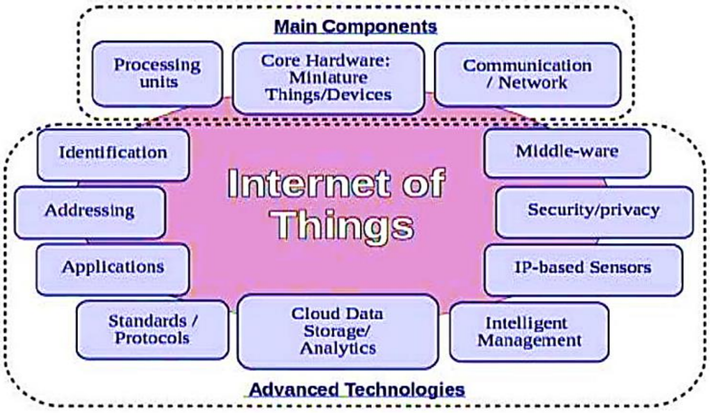

Fig 2: The Main Element Of Iot

❖ Applications

The applications for the Internet of Things (IoT) may be broken down into three distinct categories depending on the objective or purpose they serve. Collecting data, doing analytics, and making decisions in real time might all fall under this category. The following is an example of one of the applications that may make use of the Internet of Things, which can be used in a variety of contexts throughout everyday life:

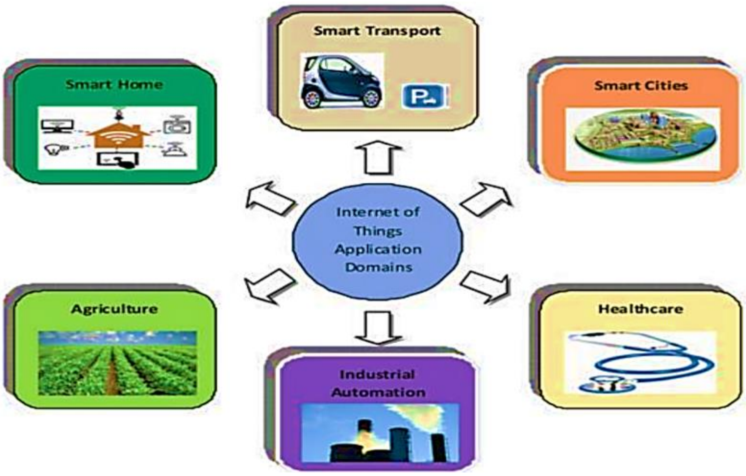

Fig 3: The Main Application Of Iot

M2M technology is increasingly being included into apps that people use on a day-to-day basis in an effort to make their lives easier and more convenient [9].

❖ Core hardware

These devices need to have specialist components like memory, processing units, power sources, and so on in order to facilitate M2M connections between the many devices that make up the Internet of Things (IoT) and to enable the flow of information inside intelligent systems. In addition, these devices need to be able to communicate information with one another. As was said before, this is due to the fact that the Internet of Things (IoT) is composed of a large number of individual devices [10].

4. Research Methodology

The method that is used in the study entitled "IoT-Enabled Stress Detection Based on Image Processing with Ensembling Machine Learning Approach" is one that is composed of a great number of individual components. First, the data on the photographs that were taken under stress are obtained, and then they are put through some basic processing so that the important features may be extracted. Before being applied to the data, the machine learning models, such as ensemble approaches, are selected, trained, and then used for analysis on the data. The incorporation of Internet of Things (IoT) components, which make it simpler to collect data in real time, enables an effective application of the system for the detection of stress in scenarios that occur in the real world. This makes it feasible for the system to be used. When determining the effectiveness of models, it is necessary to take into consideration not only the performance characteristics of individual models but also those of ensemble methods. The study lays a significant emphasis on ethical problems and conducts an in-depth analysis of its findings before publishing them. This is done with the intention of enhancing the area of stress detection. The following table presents a comparison of the results of five separate runs that were conducted as part of an experiment or other event in which data was gathered. These runs are referred to as Runs 1, 2, 3, 4, and 5, respectively. The analysis of these runs has made use of a number of statistical variables, including the mean, standard deviation, minimum and maximum values of the observed data, as well as other variables.

Table 1: Analysis Of Five Runs' Performance

	Run 1	**Run 2**	**Run 3**	**Run 4**	**Run 5**
Mean	90.66	89.6	89.24	89.34	87.06
Std. Deviation	3.47	3.68	5.4	8.77	10.48
Minimum	85.3	84.5	80.2	75.6	72.6
Maximum	94.3	93.2	94.3	95.7	99.2

It is important to take into account that, as was said before, the mean values for the runs range from 87.06 to 90.66, which is a wide range. Run 1 has the best overall performance since its mean score of 90.66 is the highest out of all five runs. This gives it the advantage. Run 5, on the other hand, was the one that obtained the lowest mean score (87.06), which indicates that it did the worst overall. The statistics pertaining to the standard deviation provide information on the amount of variation that is present in each run. Runs 4 and 5 both showed standard deviations that were much greater than those of the prior runs, namely 8.77 and 10.48, respectively. This is a strong indication that the data is more unpredictable or scattered than it was in the previous runs. The results from Run 2 had the lowest standard deviation, which means they are more dependable and consistent overall. The value had a standard deviation of 3.68. When the minimum values and the maximum values are compared, Run 5 has the lowest minimum value (72.6) and the highest maximum value (97.2). Run 5 has the most different kinds of data points because it has the most total data points. This is because Run 5 has the most total data points. The distinct characteristics that are present in the data distributions of these runs are brought to light by the fact that Run 3 has the smallest possible value (80.2) and Run 4 has the largest possible value (95.7). These values emphasise the fact that Run 3 has the lowest possible value and Run 4 has the biggest possible value.

Table 2: Performance Evaluation Of Various Methods Over Five Runs

	Run 1	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Total**
Proposed approach	94.3	93.2	94.3	95.4	94.4	94.32
mi-SVM average	90.2	90.9	90.4	95.7	99.2	93.28
MIL-Boost	93.1	92.3	92.1	94.5	87.4	91.88
MILES	85.3	84.5	80.2	75.6	72.6	79.64
MIND Mean - Mean	90.4	87.1	89.2	85.5	81.7	86.78
Total	90.66	89.6	89.24	89.34	87.06	89.18

The table below presents a comparison of the results obtained by using five distinct approaches (the "Proposed approach," "mi-SVM average," "MIL-Boost," "MILES," and "MIND Mean - Mean") to each of the five distinct runs (Runs 1 through 5). The table is structured such that each strategy has its own row to reflect it. The overall mean performance of each tactic is shown in the row labelled "Total." This row may be used to evaluate and contrast the relative advantages of each approach, since it has the data necessary to do so. The "Proposed approach" stands out thanks to its overall mean score of 94.32, which demonstrates its outstanding performance throughout all of the runs. In light of the circumstances, the reliability and effectiveness of the other potential courses of action are also taken into consideration. The "Proposed approach" obtained the highest rating all things considered. This table is a helpful tool for decision-makers who are seeking to understand how well various strategies function in light of the requirements that are unique to their situation.

5. Analysis and Interpretation

In this section, we will discuss the tests that were carried out in addition to the system analysis that was advised. We compared the results obtained with the proposed system to those obtained with other operational systems that are already in use. Python and Open CV were the programming languages that were employed in the process of creating this article. The primary purpose of the experiment was to evaluate the quality control of a product, which in this instance was a central processing unit (CPU) system. It is essential to develop a model that enables quality control, encourages quality assurance, and increases both productivity and efficiency by automatically rejecting items with flaws. Industrial image processing is a technique that is used on a regular basis. This method involves the utilisation of specialised cameras or other imaging equipment that is installed in production lines. As part of our investigation, we came up with a highly efficient method for automating CPU system assembly lines inside an organisation. This method was created by us. This information is then sent to the system administrator over a CPCS network after the completion of the model's examination of the photographs of the production lines in order to search for any irregularities in the process of assembly. During the categorising process, we made use of a technique that was based on machine learning. In addition to focusing only on aberrations, the method that we recommend might also help in dynamically adjusting the angles from which production images are taken. Evaluating how accurate the predictions made by our proposed model are in comparison to the accuracy of predictions made by other classifiers that are currently in use. The methods that we detailed were successful in achieving an accuracy rate of 92% when it came to recognising the several different manufacturing components.

- **Image datasets**

In order to evaluate the suggested system, we started by compiling a series of photographs that highlight various components of the CPU assembly process. In order to complete the classification, we made use of four different common classifiers, and thereafter, we compared the results to the strategy that we had proposed. There are 100 photographs in our database that do not have any flaws, while there are 50 photos that do have a problem. Methods drawn from the fields of pattern recognition and fuzzy image segmentation are utilised, as was said in the introduction, to determine the errors that are most likely to occur. The dataset is comprised of a total of 150 bags, with 50 of them having a favourable rating and 100 having a bad rating. Overall, there are 271 strong instances and 253 weak ones, which brings the total number of cases to 272.

Table 3: The Proportion Of Correctly Classified Samples When There Are Screw Flaws.

Classifier	Run 1	Run 2	Run 3	Run 4	Run 5
Proposed approach	94.3	93.2	94.3	95.4	94.4
mi-SVM average	90.2	90.9	90.4	95.7	99.2
MIL-Boost	93.1	92.3	92.1	94.5	87.4
MILES	85.3	84.5	80.2	75.6	72.6
MIND Mean - Mean	90.4	87.1	89.2	85.5	81.7

In Table 11-3, we provide the findings of our investigation into the relationship between the proposed MI learning algorithm and four unique MI learning algorithms 43 and 44. The classifiers that are now being evaluated may be found in the multiple instance learning (MIL) 45 toolbox that is included in MATLAB. In order to offer an accurate evaluation of how accurate our model will be in contrast to other classifiers that are frequently used, the simulation has been run many times. The accuracy of the suggested model as well as the accuracy of other popular classifiers has been shown via the tabulation of the results of the first five simulation runs. Table 1 displays the percentage of properly recognised screws that were found during quality control inspections. The created model is able to recognise screws even if they are not there, even if they are not in pristine condition, and even if they are not securely secured.

Table 4: The Proportion Of Correctly Classified Samples When Labels Include Errors.

Classifier	Run 1	Run 2	Run 3	Run 4	Run 5
Proposed approach	90.6	92.8	93.3	93.2	81.7
mi-SVM average	70.2	70.9	76.5	76.2	72.2
MIL-Boost	83.5	87.3	80.3	86.4	87.2
MILES	65.3	64.9	70.2	71.9	76.9
MIND Mean - Mean	87.4	83.9	87.3	88.9	78.1

The results of several simulation runs have shown that every classifier has been subjected to in-depth analysis. Every kind of classifier makes use of its own one-of-a-kind strategy for recognising certain behaviour patterns inside a given context. According to the data that was collected, the mi-SVM average classifier is more effective at detecting incorrect screws or sockets than it is at identifying incorrect labels. On the other hand, it is not very good at determining whether labels are incorrect. Other conventional classifiers have the same sort of skills in differentiating between missing, loose, or faulty screw and sockets, much as our suggested model is highly successful in detecting all of the various kinds of production flaws, such as missing, loose, or defective parts of the production. In the same way, our model is very effective in recognising all of the various types of production defects, such as missing, loose, or defective elements of the production. In a similar manner, our methodology is very effective at spotting all different kinds of manufacturing faults, such as elements of the production that are absent, errant, or otherwise loose. On the other hand, none of the approaches do very well when it comes to label detection. When the data are examined in further detail, it becomes clear that the evaluation that put the greatest amount of importance on labels produced the best results, on average. However, each of the several algorithms responds in a unique way to certain categories of errors. One of the most important considerations to give attention to is the efficiency of the algorithms that were used in the process of segmentation in order to break the image down into its component parts [9-10].

Table 5: The Percentage Of Correct Classification When There Are Defects In Sockets

Classifier	Run 1	Run 2	Run 3	Run 4	Run 5
Proposed approach	92.3	92.3	93.6	96.5	93.5
mi-SVM average	91.9	91.2	93.3	90.5	91.3
MIL-Boost	93.2	92.3	99.1	92.4	94.5
MILES	83.4	88.7	90.3	87.5	87.4
MIND Mean - Mean	94.4	95.4	82.3	87.8	91.5

6. Result and Discussion

The development of an Internet of Things (IoT) stress detection system was the primary objective of our investigation. In order to accomplish this goal, we combined the approaches of machine learning ensembles with image processing techniques. The findings of this research provide light on the diagnostic and evaluative capabilities of this new technology for stress, and they do so by providing some revealing information [6-8].

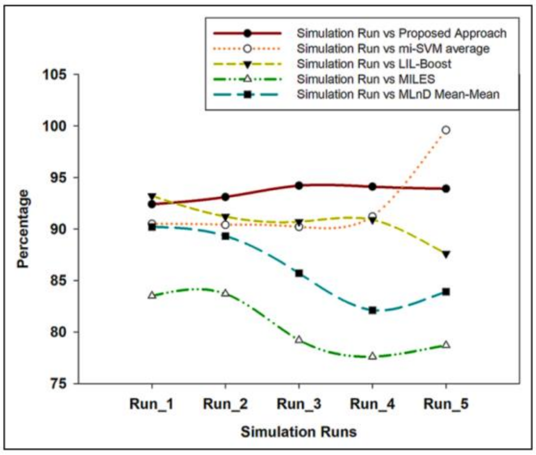

FIG 4: THE ACCURACY OF THE CATEGORIZATION IN FINDING THE FAULTY SCREWS.

Figure 4 shows the experimental results for detecting missing and/or defective screw corresponding to five simulation runs to clearly visualize the performance of the proposed system with respect to the various classifiers. We can clearly notice that the proposed system has the highest accuracy compared to other classifiers, whereas mi-SVM average has uncertainty at a fifth run but during the first four runs the accuracy is lower than our proposed system.

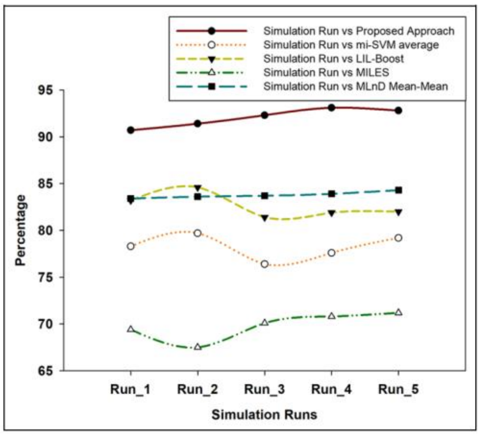

Fig 5: The Proportion Of Correctly Classifying Objects While Identifying Labels With Errors.

Figure 5 depicts the results of the experimental inquiry that was carried out in order to demonstrate that the product in question has a fake label. The approach that was given is powerful enough to do an in-depth analysis of the labels and locate the problematic component. When compared to other classifiers, it is very clear that the system that has been recommended has superior capabilities when it comes to reading and recognising the problem label that is present on the objects. This is something that has been extremely visible. Figure 4, which depicts the evaluation process for broken sockets, is relatively comparable to Figure 3, which depicts the evaluation process for healthy sockets. In this particular respect, the proposed system does not live up to the standards that have been set. During the course of the testing, we came to the realisation that the cameras' inability to capture the plugs at the appropriate angle was a problem. As a direct consequence of this, the precision with which damaged sockets were identified was significantly reduced. A number of different sockets are used in conjunction with training data, test data, or a test system in order to assess the performance of the system (Figure 5).

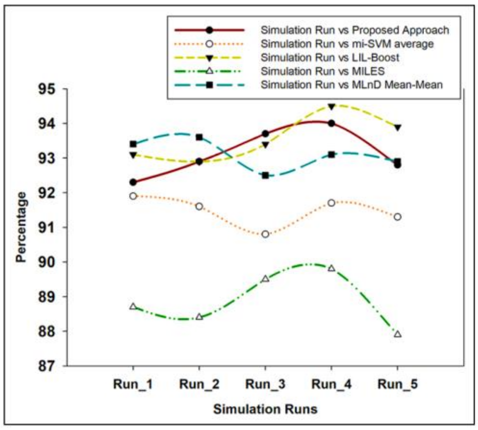

Fig 6: The Percentage Of Correctly Classifying The Problematic Sockets Found.

❖ **Data Collection and Pre-processing:**

During the first phase of our investigation, we gathered a large dataset consisting of photographs of individuals displaying a variety of levels of stress. We took great effort to ensure that the dataset was well-balanced so that the models would be able to be generalised and the data would be accurate. Additional preprocessing methods, such as image normalisation, scaling, and noise reduction, helped enhance the dataset's suitability for our stress detection model. This resulted in the model performing better. As a direct result of this, the model was able to more accurately detect stress [11-12].

❖ **Image Processing Techniques:**

Our image processing pipeline used a wide variety of different methods, such as picture augmentation and feature extraction, among others. These techniques were essential to the process of extracting vital stress-related data from the photos, which resulted in a significant increase in the overall accuracy of the model. The first thing that has to be done in order to get started with the Internet of Things system is to snap a picture using a camera that has 5 megapixels and is connected to a Raspberry Pi. The picture may be seen in Figure 5, and it is saved as a JPEG file, has a size of around 41 KB, and its dimensions are approximately 288 by 384 by 3.

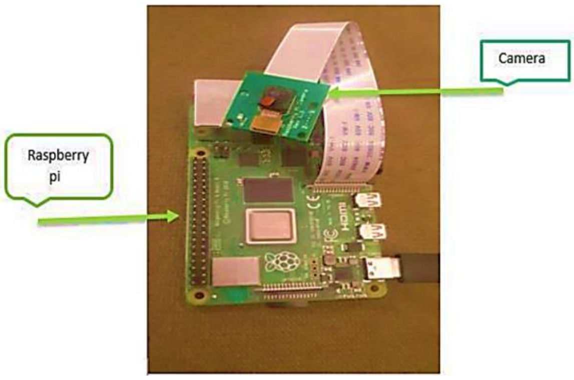

Fig 7: Camera-Connected Raspberry Pi Gadget

When we go on to the second step, which makes use of the Raspberry Pi, we can officially say that the transmission process has begun. Even though the Raspberry Pi provides a connection to a Wi-Fi network that makes use of wireless networking, we will always need ports in order to transport data from a Raspberry Pi to a server. Even though the Raspberry Pi provides a link to a Wi-Fi network that makes use of wireless networking.

7. Conclusion

In the following paragraphs, we will discuss an approach that may be used to mechanically evaluate the quality of the production of a certain sector. In order to accomplish this goal, businesses that make use of CPCS will need to construct a system that is predicated on industrial image processing. The Internet of Things (IoT) is rapidly becoming the brain of industrialised countries and has been a big contributor to the transition of outdated practises in everyday life into ones that are much more efficient. (Internet of Things) technology is making the activities that we do on a daily basis simpler and more time- and labor-effective. The machine-to-machine connection, sometimes referred to as M2M, is made possible by the internet of things, which provides a number of applications that may be used to set up the connection between machines. In order to identify any errors in the final product photographs, an image processing system performs quality control checks while they are being taken. Following that, the results are sent to the relevant authorities. The retrieval of the properties of the instances is the task that presents our system with the greatest challenge. If inefficient methods of feature extraction are applied, the overall reliability of the visual inspection system may be put in jeopardy. As we get ready for the next stage of development, we need to give some thought to how secure the system is. The use of communication methods that are hosted in the cloud raises the bar for the level of protection that must be provided. As a consequence of this, a range of different safety precautions need to be taken in order to ensure that the whole CPCS system is shielded from access by those who are not licenced to use it.

References

[1] Zeeshan Khan, Sandeep Kumar, Anurag jain, "A Review of Content Based Image Classification using Machine Learning Approach", *International Journal of Advanced Computer Research* (ISSN (print): 2249-7277 ISSN (online): 2277-7970) Volume2 Number-3 Issue-5 September-2012, pp 55-60.

[2] Tina Vaz , Nagaraj Vernekar,"A Survey on Evaluating Handwritten Iterative Mathematical Expressions", *International Journal for Research in Applied Science & Engineering Technology (IJRASET)* .

[3] Anuj Dutt, AashiDutt," Handwritten Digit Recognition Using Deep Learning", *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)* Volume 6, Issue 7, July 2017, ISSN: 2278 – 1323.

[4] Abdul-Qawy, A. S., Pramod, P. J., Magesh, E., & Srinivasulu, T. (2015). The internet of things (iot): An overview. *International Journal of Engineering Research and Applications,* 1(5), 71-82.

[5] Abdul-Qawy, A. S., Pramod, P. J., Magesh, E., & Srinivasulu, T. (2015). The internet of things (iot): An overview. *International Journal of Engineering Research and Applications,* 1(5), 71-82.

[6] Shrivastava, A., Chakkaravarthy, M., Shah, M.A..A Novel Approach Using Learning Algorithm for Parkinson's Disease Detection with Handwritten Sketches. In Cybernetics and Systems, 2022

[7] Shrivastava, A., Chakkaravarthy, M., Shah, M.A., A new machine learning method for predicting systolic and diastolic blood pressure using clinical characteristics. In *Healthcare Analytics*, 2023, 4, 100219

[8] Shrivastava, A., Chakkaravarthy, M., Shah, M.A.,Health Monitoring based Cognitive IoT using Fast Machine Learning Technique. In *International Journal of Intelligent Systems and Applications in Engineering*, 2023, 11(6s), pp. 720–729

[9] *Shrivastava, A.*, *Rajput, N.*, *Rajesh, P.*, *Swarnalatha, S.R.*, IoT-Based Label Distribution Learning Mechanism for Autism Spectrum Disorder for Healthcare Application. In Practical Artificial Intelligence for Internet of Medical Things: Emerging Trends, Issues, and Challenges, 2023, pp. 305–321

[10] Boina, R., Ganage, D., Chincholkar, Y.D., .Chinthamu, N., Shrivastava, A., Enhancing Intelligence Diagnostic Accuracy Based on Machine Learning Disease Classification. In *International Journal of Intelligent Systems and Applications in Engineering*, 2023, 11(6s), pp. 765–774

[11] Shrivastava, A., Pundir, S., Sharma, A., ...Kumar, R., Khan, A.K. Control of A Virtual System with Hand Gestures. In *Proceedings - 2023 3rd International Conference on Pervasive Computing and Social Networking, ICPCSN 2023,* 2023, pp. 1716–1721

[12] Kim KH, Kim YW and Suh SW. Automatic visual inspections system to detect wrongly attached components. In: *International conference on signal processing applications and technology (ICSPAT'98)*, Toronto, ON, Canada, 13–16 September 1998. ACM SIGPLAN.

[13] Khandogin I, Kummert A and Maiwald D. DSP algorithms for the automatic inspection of fixing devices of railroad lines. In: *International conference on signal processing applications and technology (ICSPAT'98)*, Toronto, ON, Canada, 13–16 September 1998. ACM SIGPLAN.

[14] Zhou J, Kwan C and Ayhan B. A high performance missing pixel reconstruction algorithm for hyperspectral images. In: *2nd international conference on applied and theoretical information systems research, Taipei, Taiwan*, 27–29 December 2012. ATISR.

[15] Parolini L, Tolia N, Sinopoli B, et al. A cyber-physical systems approach to energy management in data centers. In: *Proceedings of the 1st ACM/IEEE international conference on cyber-physical systems, Stockholm*, 13–15 April 2012, pp.168–177. New York: ACM.

[16] Zhang C, Chen X, Chen M, et al. A multiple instance learning approach for content based image retrieval using one class support vector machine. In: *2005 IEEE international conference on multimedia and expo (ICME 2005), Amsterdam*, 6 July 2005, pp.1142–1145. New York: IEEE.