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Part Presence Detection and Counting using Advanced Image Processing

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ABSTRACT

Part presence detection, part counting and part inspection are major steps involved during quality inspection in various stages of production in any production line. Quality inspection in most industries is done by quality inspectors or operators depending on the stage of production. Visual inspections by humans can cause variations in accuracy and results due to difference among workers. Part presence can be detected by using electronic/electrical sensors. But in cases where there is a large number of components/parts, the number of sensors to be used also increases. This leads to development of complex systems. As the need for Factory automation has increased in recent times, there is a need to increase the rate of production. Replacing manual intervention with automated system is an ideal solution. This can be successfully achieved by introducing machine vision and image processing technologies in the automated process. Since machine vision offers high image transmission and high image processing it is easier to achieve reliable and accurate results. Systems that provide these solutions are already available in market. But these systems are highly expensive and only target large scale customers that can afford such solutions. This arises a need for solutions that are cost effective and reliable to target customers with simpler image processing requirements. The main objective of this project is to develop and provide such simple low-cost machine vision solutions to customers.

Keywords- Image Processing, Visual Studio, Open CV, Part presence, Part Inspection, Part Counting, Multi

Scale Pattern Matching, Factory Automation, Machine Vision

1. INTRODUCTION

Part Presence Detection is used to check the presence/absence of components or parts on target/fixture. It can be also used to obtain the quantity of components or parts on the desired target or fixture. The various application of part presence detection are:

- Counting Bottles on a Conveyor
- Checking for presence of screws on parts that are essential for securing parts
- Counting of labels on packages
- Checking for presence of electronic components on PCBs
- Counting PCBs in stacks

Part presence detection and inspection is a major element of quality inspection during packaging or shipment on various production lines. This is widely applied in various industries. Part presence detection in most industries is done manually by operators. But this involves a risk of human errors and variation in accuracy depending on various factors such as lighting of the room, experience of operators, time of day etc. In cases where there are complex parts to be detected, manual vision inspection requires extra time and labor.

To reduce such human errors and to improve work efficiency, image processing can be introduced for part presence, inspection and counting tasks. Hence image processing can replace human eyes for recognizing and judging components in their environments. As factory automation has increased during the recent years, there is

a dire need to increase production. This can be successfully achieved by introducing machine vision and image processing technologies into the automation process.

Machine Vision offers faster image transmission and image processing so as to achieve reliable results. This can increase work efficiency and also reduce labour costs. Various industrial processes can be automated without the need of human intervention. Image processing and machine vision can be applied widely in various industries such as automotive, food, electronic devices, pharmaceutical etc. These machine vision solutions will eventually become in-dispensible in Factory Automation.

Systems that provide these solutions are already available in market. But these systems are highly expensive and only target large scale customers that can afford such solutions. This arises a need for solutions that are cost effective and reliable to target customers with simpler image processing requirements.

The main objective of the proposed system is to develop and provide such simple low-cost machine vision solutions to customers. Systems that provide these solutions are already available in market. But these systems are highly expensive and only target large scale customers that can afford such solutions. This arises a need for solutions that are cost effective and reliable to target customers with simpler image processing requirements. The main objective of the proposed system is to develop and provide such simple low-cost machine vision solutions to customers



Fig 1.1 Image of bottles in cardboard box



Fig 1.2 Image of components on fixture

2. PROPOSED SYSTEM

The main objective of the project is to develop a low-cost Machine Vision (MV) solution for part presence detection and counting. The user interface has been developed on .NET platform and Open CV libraries are used for implementing various image processing functions on captured image. The system receives live images from web camera. Image processing can be done on both live images and pre saved images.

The basic principle of operation starts with the operator training a model by either capturing a live image or uploading an image of the desired part/component. While training the model the operator has to also specify a count limit for the number of components that have to be present while running the live mode. In live mode, the operator should select the model to be tested. The set of components to be tested should be placed in parallel to the camera mounting to achieve best results. Once the operator starts the process, the image is captured using webcam. The image processing algorithms are executed on the captured image to remove various background noises and to enhance the image. The image is then compared to the already saved trained image for the selected model. Image processing algorithms such as multi scale template matching are executed to find the count of components present in the captured image. Once the count is received, the output count is compare to the pre-defined count. If the count values match, the system generates a PASS else it generates a FAIL.

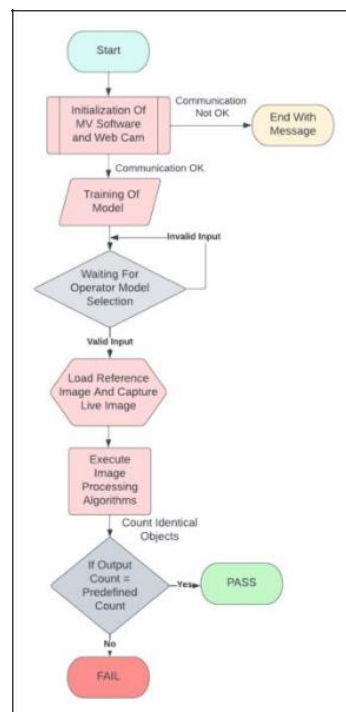


Fig 2.1 Overall Block Diagram of Proposed System

3. PHASES OF OPERATION

The Proposed System has two major phases of operation

- Training A Model
- Testing In Live Mode

This section will explain in detail these two phases of operation.

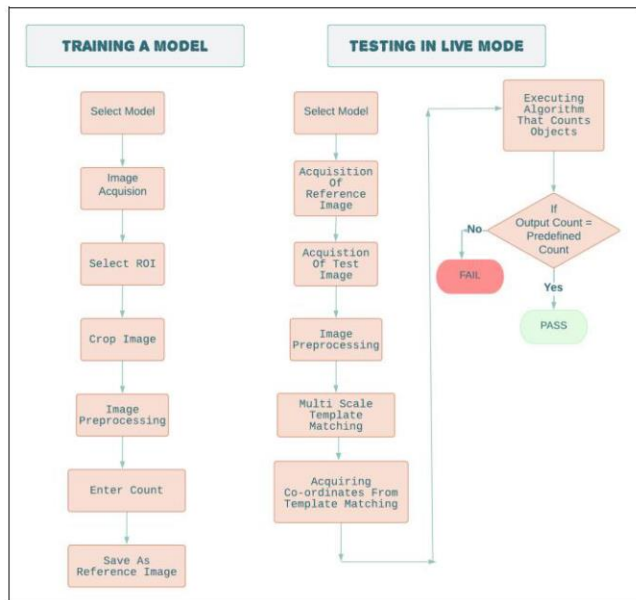


Fig 3.1 Flow Chart for the Two Modes of Operation

3.1 Training a Model

The process starts with selecting a model name. Once model selection is done, a reference image has to be set for the selected model. This can be done by either uploading the reference image or capturing a live image using a web camera. After image acquisition, the user has to select a Region of Interest (ROI) from the acquired reference image. This is required to accurately extract the major features of the reference object. The reference image is then cropped to the ROI chosen by the user. Image preprocessing algorithms are applied to the new reference image to enhance its features such as noise removal. A count value has to be entered by the user, this value will be used during live mode to check the validity of the test image. The last step of this phase of operation is to save the count value and the enhanced reference image against the selected model name. The flow chart for the above process is depicted in fig 3.1.

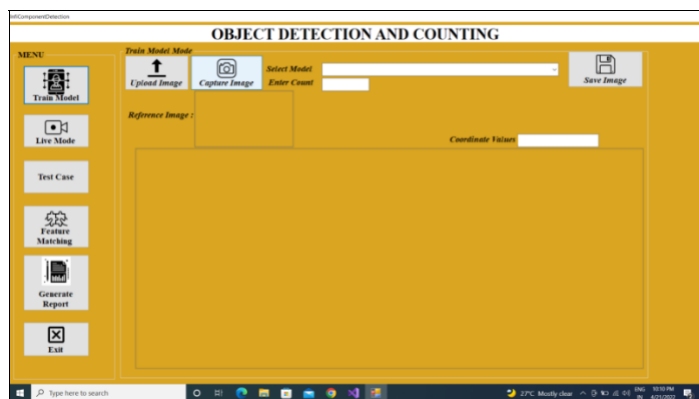


Fig 3.1.1 Train Model Mode Screen of MV Software for Object Detection and Counting

3.2 Testing in Live Mode.

The process starts with selecting a model. This model must be previously trained. After selecting the model, the reference image saved for the model during training is loaded. Now the system will wait for a test image. The user can upload pre saved image or capture a live image to start the test operation. Once the test operation begins, the test

image undergoes various image pre-processing algorithms.

Multi Scale Template matching algorithm is then applied to the reference image and the test image. The reference image is treated as the template image. The test image is continuously scanned for matching templates. Template matching is an algorithm that can help locate certain distinct features of the template image. It works by sliding the template image over the test image. As it slides it compares or matches the template to the portion of the test image directly under it. The matching is done by calculating a number, which denotes the extent to which the template and the portion of the test image matches. Multi Scale Template matching algorithm is used to detect multiple objects. This algorithm generates a set of coordinate values of portions of test image that matches the template.

These coordinate values are stored in an array. Since the template matching algorithm scans the test image multiple times, there will be multiple coordinate values generated for the same portion of the test image. These coordinate values for a portion will differ slightly from each other, hence treated as a separate point. Thus counting these generated coordinate values fails to give the correct count of the No of objects present in the image.

To overcome this issue, an algorithm is developed to scan through the co-ordinate value array and eliminate the duplicate points for a single portion. The output of this algorithm is a list of unique co-ordinate values. The count of the No of elements in the output list gives the exact count of the No of matched objects detected. This count is then compared to the predefined count defined by the user during training of the model. If the count matches the reference count, the software generates a PASS status for the current test case else it generates a FAIL status. The flow chart for the above process is depicted in fig 3.1

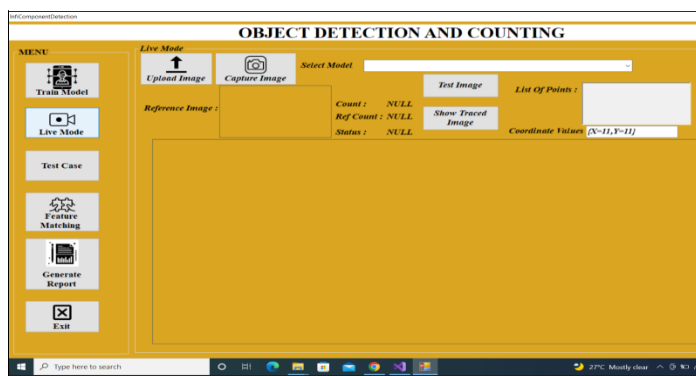


Fig 3.2.1 Live Mode Screen of MV Software for Object Detection and Counting

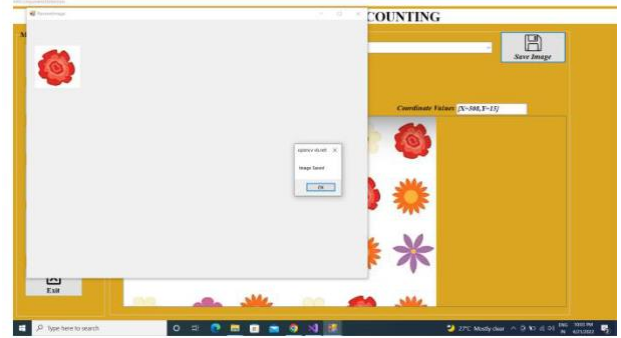
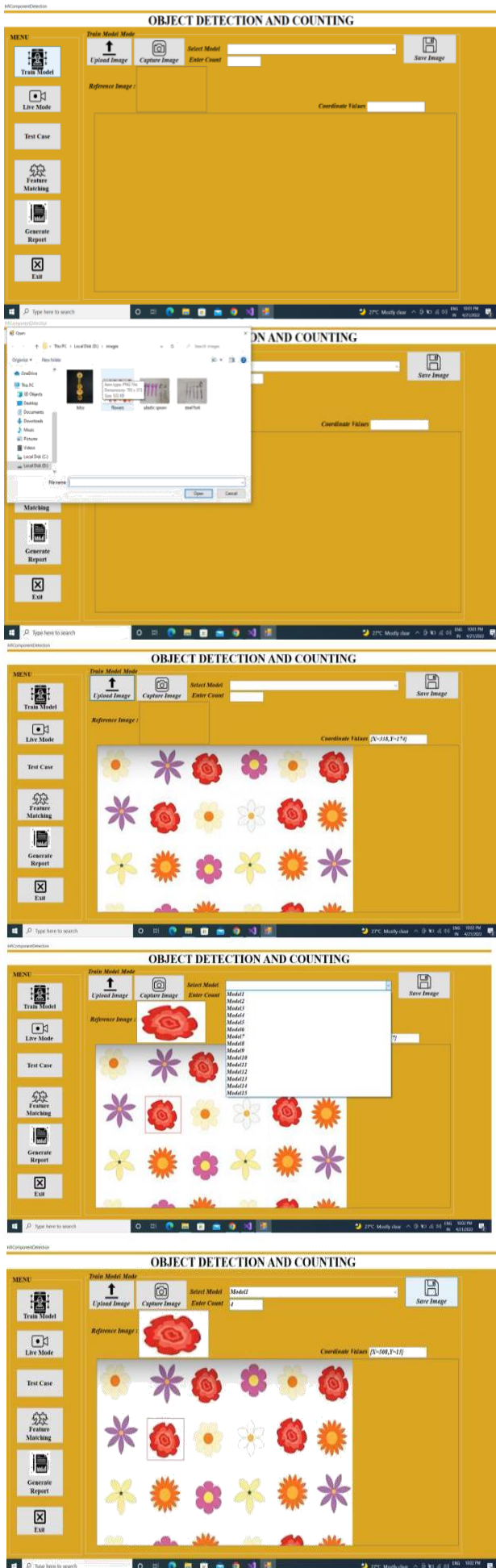
4. TEST CASES, SOFTWARE IMPLEMENTATION AND RESULTS

4.1 TEST CASE 1: Counting a Specific Flower from a Set of Flowers of Mixed Variety

4.1.1 Training the Model

In this test case the user uploaded a pre-saved image of a set of flowers as reference image during model training

mode. The model name selected for this test case is Model 1. The predefined count was given as 4.

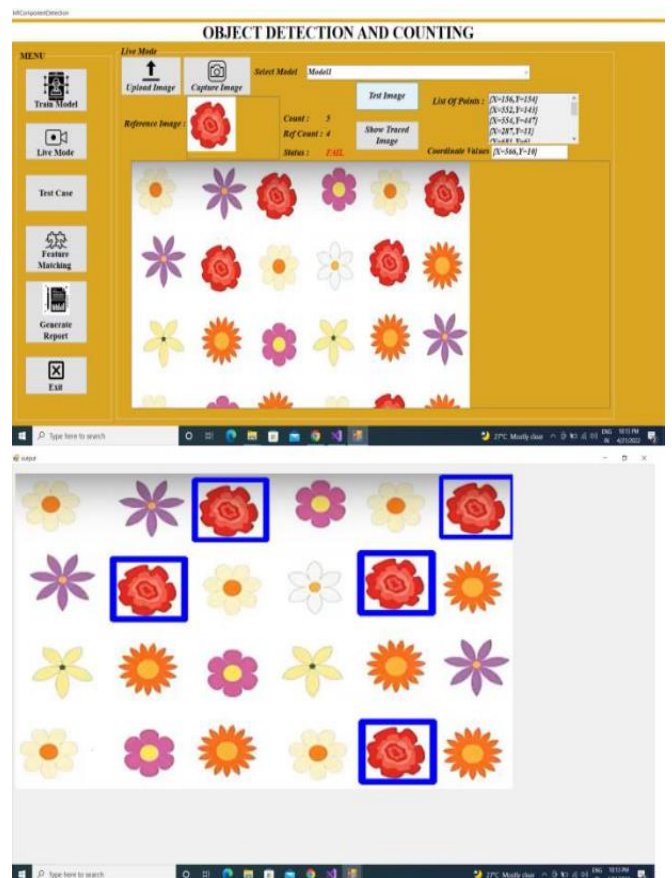


4.1.2 Testing In Live Mode

In Live Mode, once Model is selected the reference image along with the predefined count value is loaded that was previously saved during model training. The test image is uploaded. The testing operation starts when the Test Image button is pressed.

4.1.3 Results

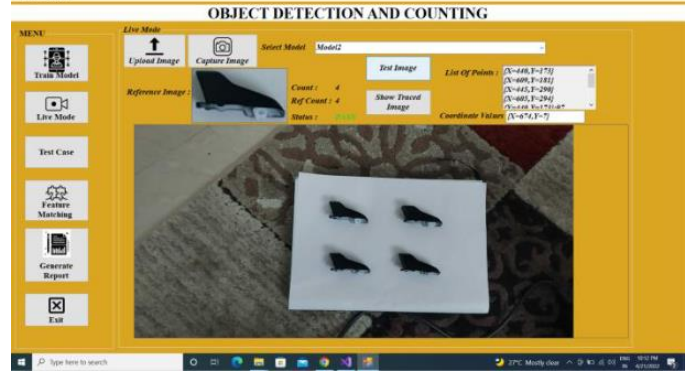
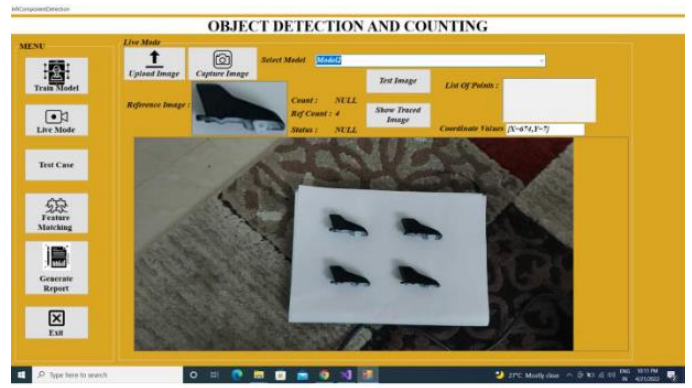
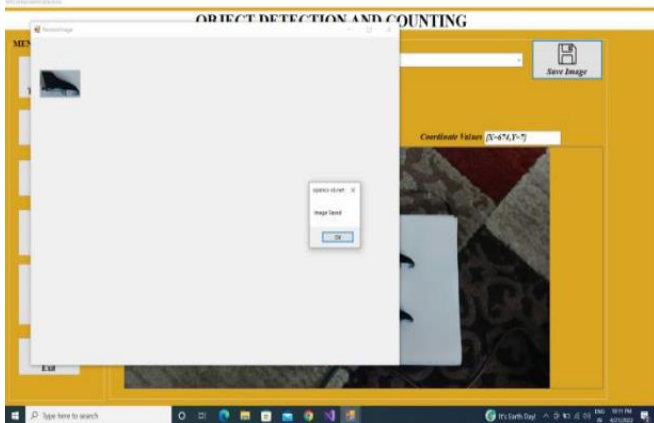
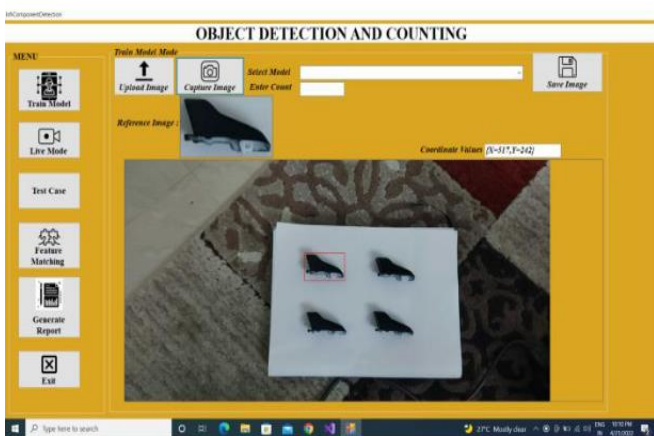
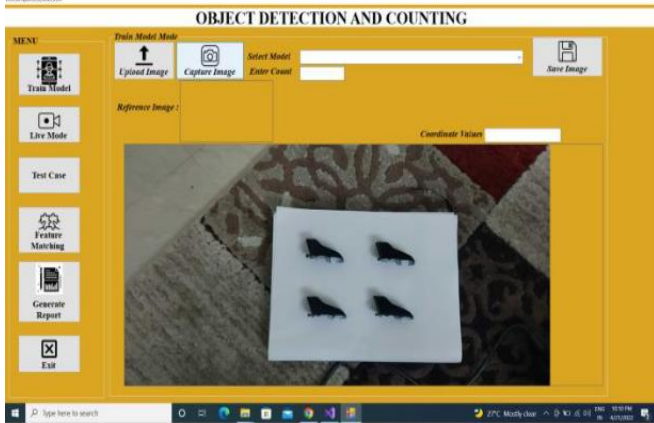
An Output status is generated once the testing operation is completed. For this test case, the output status is a FAIL. Since the number of objects detected does not match the pre-defined value. The traced location of the objects counted by the software is displayed in a separate dialog box when Show Traced Image button is pressed.



4.2 TEST CASE 2: Counting Automotive Components

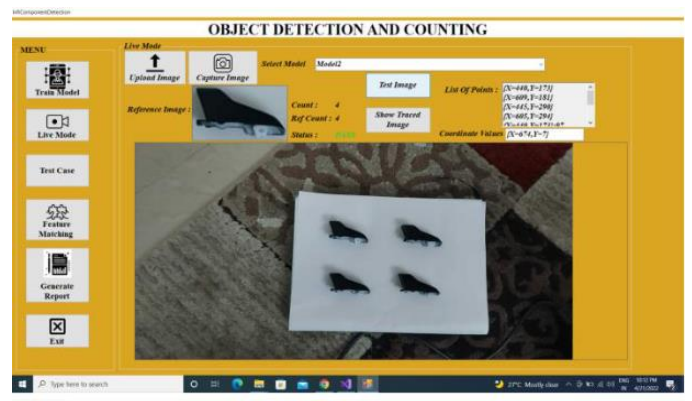
4.2.1 Training the Model

In this test case the user captured a live image using a web camera in the model training mode. The ROI was then restricted to one of the components and training algorithm was applied to the image. The model name selected for this test case is Model 2. The predefined count was given as 4.



4.2.3 Results

An Output status is generated once the testing operation is completed. For this test case, the output status is a PASS. The number of objects detected matches the pre-defined value i.e. 4. The traced location of the objects counted by the software is displayed in a separate dialog box when Show Traced Image button is pressed.



4.2.2 Testing In Live Mode

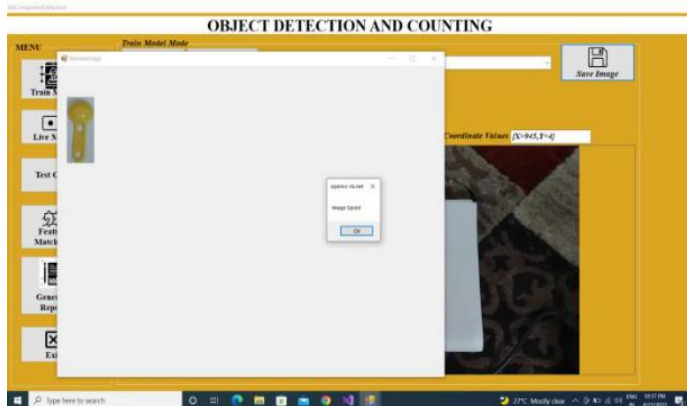
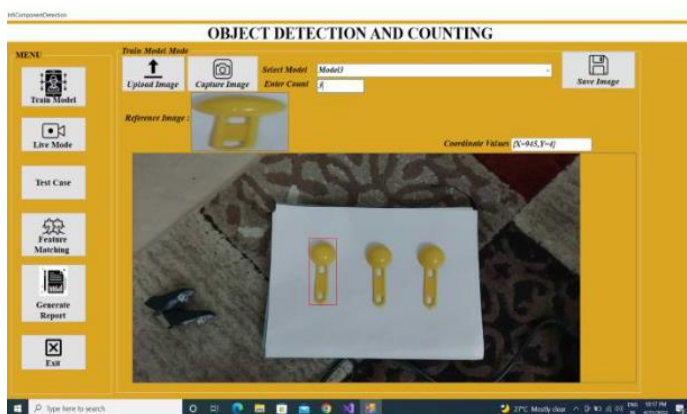
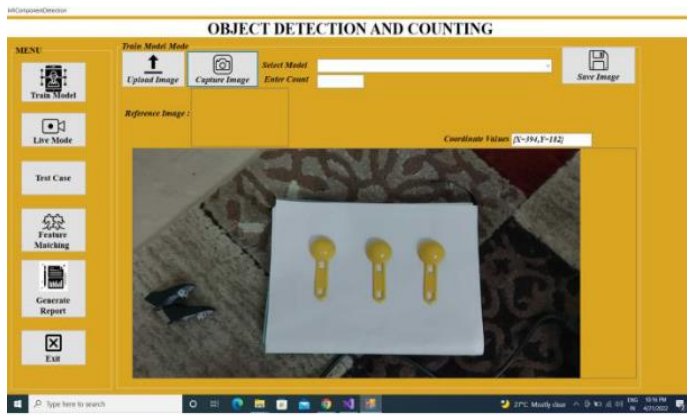
In Live Mode, once Model is selected the reference image along with the predefined count value is loaded that was previously saved during model training. The test image is uploaded. The testing operation starts when the Test Image button is pressed.

4.3 TEST CASE 3: Counting Plastic Spoons

4.3.1 Training the Model

In this test case the user captured a live image using a web camera in the model training mode. The ROI was then restricted to one of the components and training algorithm

was applied to the image. The model name selected for this test case is Model 3. The predefined count was given as 3.



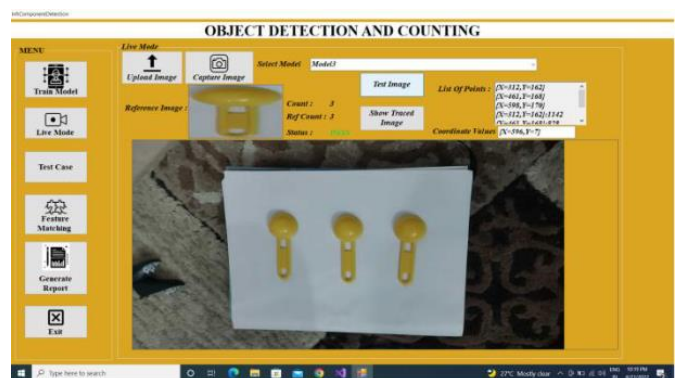
4.3.2 Testing In Live Mode

In Live Mode, once Model is selected the reference image along with the predefined count value is loaded that was previously saved during model training. The test image is uploaded. The testing operation starts when the Test Image button is pressed.



4.3.3 Results

An Output status is generated once the testing operation is completed. For this test case, the output status is a PASS. The number of objects detected matches the pre-defined value i.e. 4. The traced location of the objects counted by the software is displayed in a separate dialog box when Show Traced Image button is pressed.



5. CONCLUSION

In this Machine Vision (MV) Based system, a low cost solution for part presence detection and counting was proposed and implemented to train, identify, detect and count various types of industrial components. A .NET and Open CV based Software has been developed to capture and train a model/object such that when given an input as an image of

a set of components it detects them and generates an accurate count of the No. of components present in the image. It also generates a PASS or FAIL depending on whether the count value matches the pre-defined count value.

The main advantage of this solution is that it is customizable. Since all the image processing is done by the software, the only hardware requirement is an industrial grade camera (without any high memory requirements) to capture the live images. The software is designed such a way that it can communicate to any type of camera.

The proposed system using various image processing algorithms works effectively for all test cases as shown in the results section. The system is highly sensitive to rotation and scaling. New algorithms have to be developed to optimize the solution so as to reduce this sensitivity. It would be considered for future work.

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