Leather Defect Detection System Using Machine Learning

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ABSTRACT

The quality of leather products is significantly influenced by the presence of surface defects such as scratches, wounds, insect bites, tanning irregularities, and texture variations. Traditionally, leather inspection is performed manually by trained workers, a process that is highly time-consuming, inconsistent, and subjective. With increasing demand for high-quality leather goods and the need for standardization in quality assurance, automated defect detection systems have become essential. This project proposes a deep learning–based approach for automated leather defect detection using the MobileNetV2 Convolutional Neural Network (CNN) architecture, specifically designed for efficient image classification tasks.

The system utilizes a comprehensive data set of leather images, categorized into defective and non-defective classes. The methodology includes image acquisition, preprocessing, augmentation, feature extraction, and model training. MobileNetV2 is chosen for its lightweight structure, fast computation, and strong performance on image recognition tasks. The model architecture is enhanced with additional dense layers, dropout regularization, and a soft max classifier to improve generalization and accuracy. A systematic training and validation process is conducted using augmented datasets to ensure robustness against variations in lighting, orientation, and texture.

*Experimental results demonstrate that the proposed model achieves **98% accuracy** on the MVTEC anomaly detection data set, effectively distinguishing between defective and non-defective leather surfaces. The system not only identifies defects but also ensures consistent evaluation standards across all inspected samples. A user-friendly interface is developed to enable real-time detection, allowing users to upload an image and receive instant defect classification results.*

The automated approach significantly reduces manual labor, minimizes inspection time, and increases overall production efficiency. This research validates the effectiveness of deep learning in industrial quality inspection and highlights its potential for large-scale deployment in leather manufacturing units. Future work may include incorporating advanced AI models, expanding the defect categories, integrating segmentation for precise defect localization, and deploying the system on edge devices for real-time industrial automation.

Keywords: *Convolutional Neural Network (CNN), AI, ML.*

INTRODUCTION

Leather is prepared by using the skin of animals such as sheep, buffalo, goat, etc. The leather industries in India plays an important role in the Indian economy. India is now ranked second in the world for footwear and leather garment manufacture. The leather business is a large employer, employing over 4.42 million people, the majority of whom are from lower socioeconomic groups. The defects on a leather surface may be caused by the poor material handling process during the manufacturing and production stages. ST Liong use a deep learning approach to propose an automatic flaw identification system. The suggested method is divided into two steps, namely categorization and instance segmentation. The first stage determines whether the leather sample contains a defective part or not, and the second determines the precise position of the defect. SR Khanal showed their research is to completely automate fault detection based on cutting-edge machine vision techniques to replace the traditional process of leather inspection. ST Liong studied calf leather, and a completely automatic fault detection and tagging method was suggested. A deep learning architecture is used to identify the location of the leather faults using a machine vision method. Z Chen examine and assess the effectiveness of a few edge and threshold detectors for leather defect detection, as well as the identification precision of the traditional SVM machine learning method. W Xuekun the no detection zone as well as the effective zone of defects presented an orthogonal state, according to an experimental study on the defects of imprinting and ink that was conducted to demonstrate how these two types of defects feature light intensity distributions that were related to the lighting direction. K. Hoang in their project, a system for grading leather hides using machine vision has been created. Y.S. Gan a system for classifying leather defects automatically is presented. On a particular kind Corresponding author of calf leather, we concentrate on finding tick-bite flaws. To represent the leather patches, both

manually created feature extractors (such as edge detectors and statistical approaches) and data-driven (such as artificial neural network) methods are used. Then, a variety of classifiers are used to determine whether the test sample patches contain defective segments, including decision trees, Support Vector Machines, closest neighbor, and ensemble classifiers. Tariq M. Khan the creation of a dataset of annotated wetblue leather images, the transfer of knowledge from other domains to the domain of leather images, and the design of ensemble networks

specifically for the task are three key topics they cover in their discussion of the identification of industrial leather defects. M Jawahar studied leather surface images captured using a machine vision system. A novel multi-level thresholding algorithm was then used to segment the leather into defective and non-defective regions, and texture feature extraction was used to quantitatively measure the leather surface flaws. The goal of this research study, to classify leather surface defect and non-defect detection. As well as the accuracy of the MobileNet V2 based leather surface defect identification.

2-REQUIREMENT ANALYSIS

Taking into account the comparative analysis stated in the previous section we could start specifying the requirements that our website should achieve. As a basis, an article on all the different requirements for software development was taken into account during this process. We divide the requirements in 2 types: functional and nonfunctional requirements.

FUNCTIONAL REQUIREMENTS

These are the requirements that the end user specifically demands as basic facilities that the system should offer. All these functionalities need to be necessarily incorporated into the system as a part of the contract. These are represented or stated in the form of input to be given to the system, the operation performed and the output expected. They are basically the requirements stated by the user which one can see directly in the final product, unlike the non-functional requirements.

MODULES:
User:
Upload Image View Output
System:
Image Acquisition   Annotated Dataset Collection
Image Processing
Feature-Extraction Classification Deployment

NON-FUNCTIONAL REQUIREMENTS
These are basically the quality constraints that the system must satisfy according to the project contract. The priority or extent to which these factors are implemented varies from one project to other. They

are also called non-behavioral requirements. They basically deal with issues like:
➢ Portability
➢ Maintainability
➢ Reliability
➢ Scalability
➢ Performance
➢ Reusability
➢ Flexibility

COMPUTATIONAL RESOURCE REQUIREMENTS

HARDWARE REQUIREMENTS

➢ Processor : Intel i5
➢ RAM : 8 GB
➢ Hard Disk : 500 GB

SOFTWARE REQUIREMENTS
➢ Programming Language : Python 3.12
➢ IDE : Jupyter notebook
➢ Operating System : Window 10
➢ Front -end : HTML, CSS, java script

3-DESIGN

ARCHITECTURE

Project architecture represents number of components we are using as a part of our project and the flow of request processing i.e. what components in processing the request and in which order. An architecture description is a formal description and representation of a system organized in a way that supports reasoning about the structure of the system. Architecture is of two types. They are

(1) Software Architecture
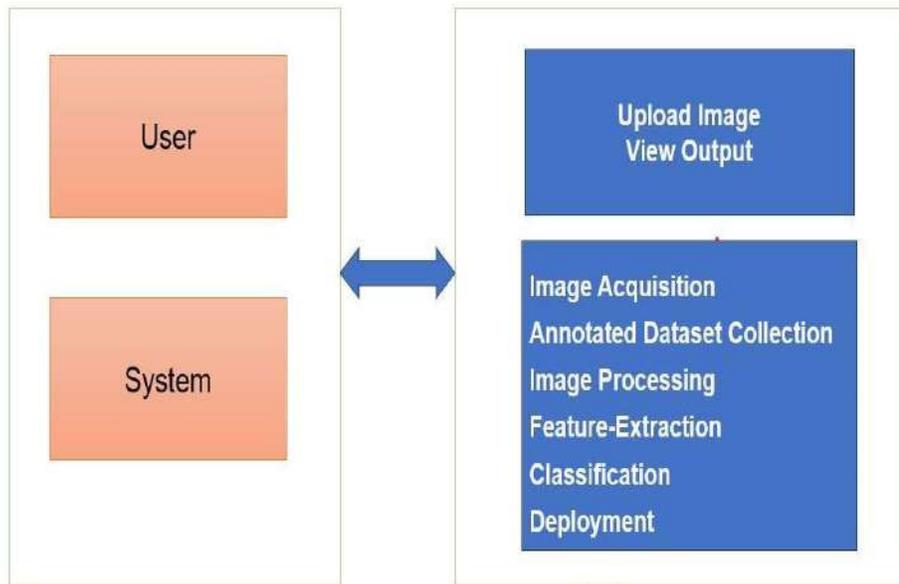(2) Technical Architecture

SYSTEM ARCHITECTURE

Fig 1 System Architecture
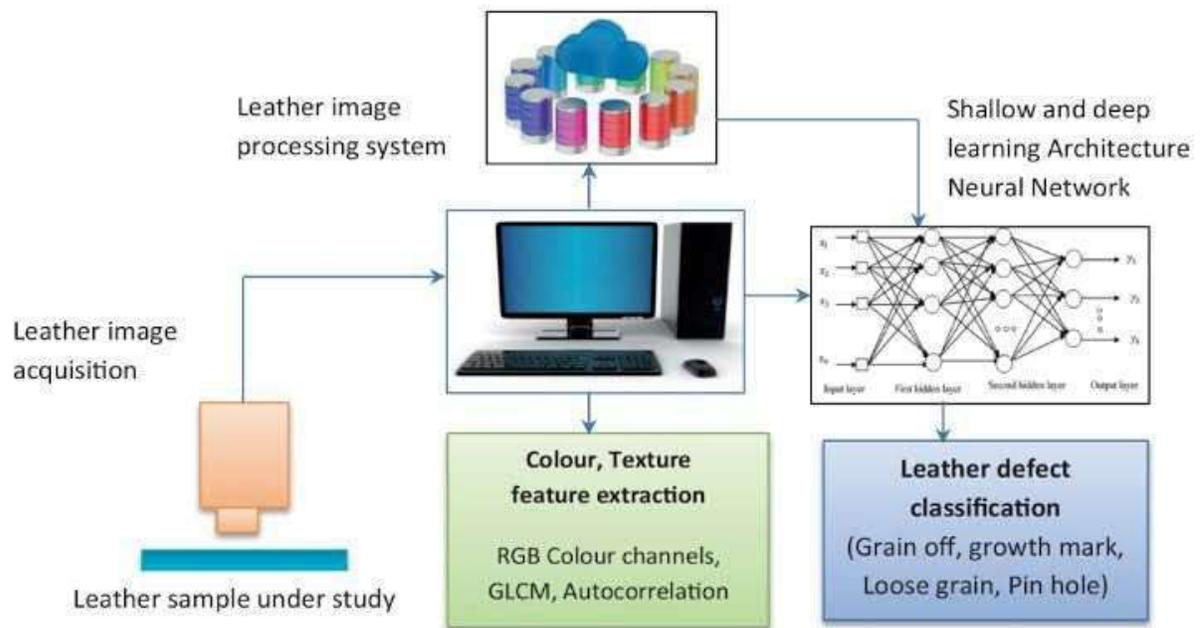
TECHNICAL ARCHITECTURE

Fig 2 Technical Architecture

visual data.

When it comes to Machine Learning, perform really well. Neural Networks are used in various datasets like images, audio, and text. Different types of Neural Networks are used for different purposes. It is widely used in image recognition, classification, and computer vision tasks.
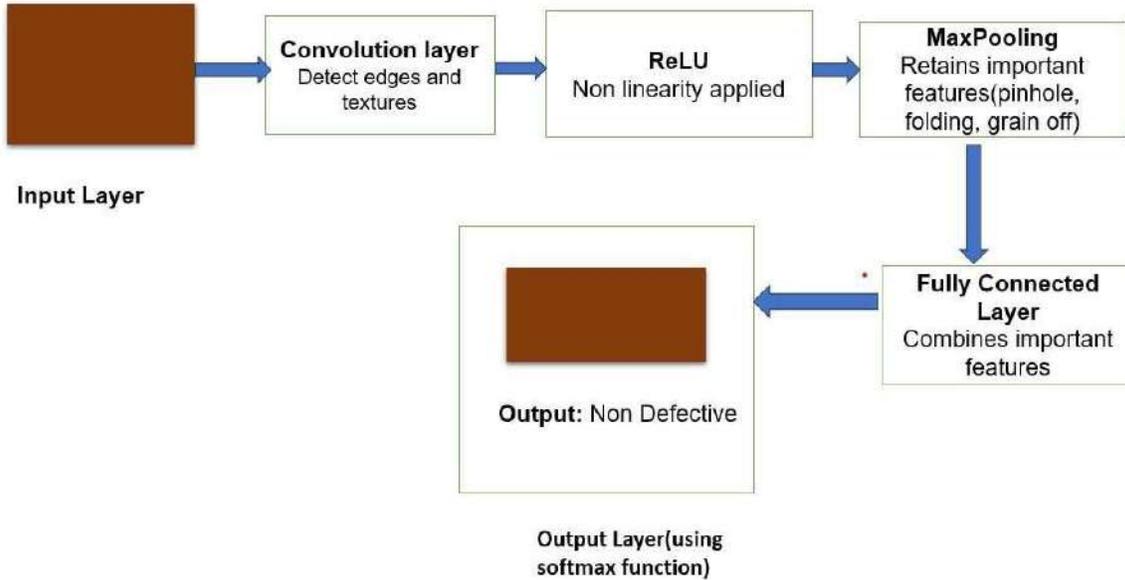
4-ALGORITHM
CONVOLUTIONAL NEURAL NETWORK

A Convolutional Neural Network (CNN) is a type of Deep Learning neural network architecture commonly used in Computer Vision. Computer vision is a field of Artificial Intelligence that enables a computer to understand and interpret the image or

Fig.3 CNN Algorithm

1.2 IMPLEMENTATION OF ALGORITHM

Input:

• When the image is given as input to the system, (rows x columns x channels)

the system will read the image as three channels (R, G, B) each of the channels have respective pixels.
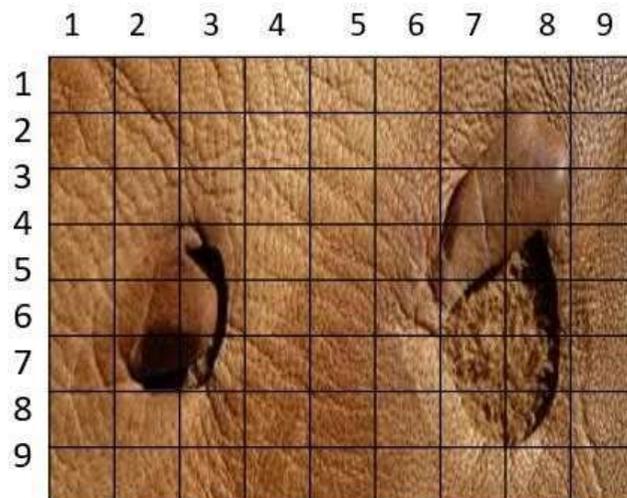
• The image is considered as

Fig 4 Input

5-IMPLEMENTATION

PYTHON

Python is an interpreter, object-oriented, high-level programming language with dynamic semantics. Its high-level built in data structures, combined with dynamic typing and dynamic binding, make it very attractive for Rapid Application Development, as well as for use as a scripting or glue language to connect existing components together. Python's simple, easy to learn syntax emphasizes readability and therefore reduces the cost of program maintenance. Python supports modules and packages, which encourages program modularity and code reuse. The Python interpreter and the extensive standard library are available in source or binary form without charge for all major platforms, and can be freely distributed. Often, programmers fall in love with Python because of the increased productivity it provides. Since there is no compilation step, the edit-test-debug cycle is incredibly fast. Debugging Python programs is easy: a bug or bad input will never cause a segmentation fault. Instead, when the interpreter discovers an error, it raises an exception. When the program doesn't catch the exception, the interpreter prints a stack trace. A source level debugger allows inspection of local and global variables, evaluation of arbitrary expressions, setting breakpoints, stepping through the code a line at a time, and so on. The debugger is written in Python itself, testifying to Python's introspective power. On the other hand, often the quickest way to debug a program is to add a few print statements to the source: the fast edit-test-debug cycle makes this simple approach very effective.

The Python programming language is an Open Source, cross-platform, high level, dynamic, interpreted language.

The Python 'philosophy' emphasizes readability, clarity and simplicity, whilst maximizing the power and expressiveness available to the programmer. The ultimate compliment to a Python programmer is not that his code is clever, but that it is elegant.

For these reasons Python is an excellent 'first language', while still being a powerful tool in the hands of the seasoned and cynical programmer.

Python is a very flexible language. It is widely used for many different purposes. Typical uses include:

- Web application programming with frameworks like Zope, Django and Turbogears

- System administration tasks via simple scripts

- Desktop applications using GUI toolkits like Tkinter or wxPython (and recently Windows Forms and Iron Python)

- Creating windows applications, using the Pywin32 extension for full windows integration and possibly Py2exe to create standalone programs

- Scientific research using packages like Scipy and Matplotlib Good to know

JUPYTER NOTEBOOK

The Jupyter Notebook is an open-source web application that allows you to create and share documents that contain live code, equations, visualizations and narrative text. Uses include: data cleaning and transformation, numerical simulation, statistical modeling, data visualization, machine learning, and much more.

Jupyter Notebooks are a powerful way to write and iterate on your Python code for data analysis. Rather than writing and re-writing an entire program, you can write lines of code and run them one at a time. Then, if you need to make a change, you can go back and make your edit and rerun the program again, all in the same window.

6-TESTING

Software testing is an investigation conducted to provide stakeholders with information about the quality of the product or service under test. Software Testing also provides an objective, independent view of the software to allow the business to appreciate and understand the risks at implementation of the software. Test techniques include, but are not limited to, the process of executing a program or application with the intent of finding software bugs.

Software Testing can also be stated as the process of validating and verifying that a software program/application/product:

- Meets the business and technical requirements that guided its design and Development.

- Works as expected and can be implemented with the same characteristics.

FUNCTIONAL TESTING

Functional tests provide systematic demonstrations that functions tested are available as specified by the business and technical requirements, system documentation, and user manuals.

Functional testing is centered on the following items:

- Functions: Identified functions must be exercised.

- Output: Identified classes of software outputs must be exercised.

- Systems/Procedures: system should work properly

INTEGRATION TESTING

Software integration testing is the incremental integration testing of two or more integrated software components on a single platform to produce failures caused by interface defects.

Here in machine learning we are dealing with a

dataset which is in excel sheet format so if any test case we need means we need to check excel file.

Later on classification will work on the respective columns of the dataset.

7-SCREENSHOTS

Screenshot 7.1 open jupyter Notebook

Screenshot 7.2 To Activate Project

Screenshot 7.3 Copy URL

Screenshot 7.4 Paste URL in the Chrome
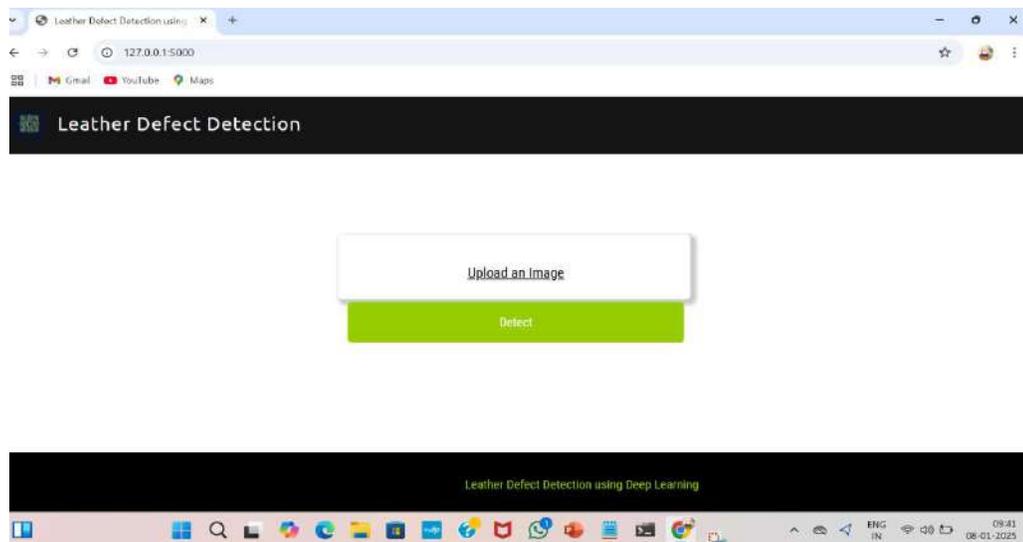
Screenshot 7.5 Click on Upload an Image Button

8-CONCLUSION

In this research, leather defect detection based on the MobileNet V2 model has been designed and implemented. We evaluated this method on the MVTEC anomaly detection dataset consisting of images of goods and anomalies. In training the network, the custom MobileNet V2 model was used, and iterative training is performed for 20 epochs to evaluate its performance. The experiments show that our model can classify the image sample into the correct image class and indicate whether it contains defect or not. This model achieves a high accuracy of 98% of the correct defect detection rate on the MVTEC anomaly detection dataset.

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