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A Deep Learning-Based Experiment on Forest Wildfire Detection in Machine Vision Course

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Abstract

As an interdisciplinary course, Machine Vision combines AI and digital image processing methods. This paper develops a comprehensive experiment on forest wildfire detection that organically integrates digital image processing, machine learning and deep learning technologies. Although the research on wildfire detection has made great progress, many experiments are not suitable for students to operate. Also, the detection with high accuracy is still a big challenge. In this paper, we divide the task of forest wildfire detection into two modules, which are wildfire image classification and wildfire region detection. We propose a novel wildfire image classification algorithm based on Reduce-VGGnet, and a wildfire region detection algorithm based on the optimized CNN with the combination of spatial and temporal features. The experimental results show that the proposed Reduce-VGGNet model can reach 91.20% in accuracy, and the optimized CNN model with the combination of spatial and temporal features can reach 97.35% in accuracy. Our framework is a novel way to combine research and teaching. It can achieve good detection performance and can be used as a comprehensive experiment for Machine Vision course, which can provide the support for talent cultivation in machine vision area.

1. INTRODUCTION

With the rapid development of computer technology and the popularity of cameras, machine vision technology based on artificial intelligence (AI) and digital image processing has been applied to increasing fields, such as face detection , wildfire detection, object measurement and surface defect detection. As an interdisciplinary course, Machine Vision combines AI and digital image processing. With the development of AI, machine vision can replace human beings with intelligent programs for some automated operations and measurements. A complete machine vision system includes a camera and an image processing device. The associate editor coordinating the review of this manuscript and approving it for publication was Senthil Kumar . The camera firstly obtains the images, then we can recognize the target object through the computer's visual recognition algorithm, and finally the image processing device can output the target recognition result through the terminal. At present, machine vision has become one of the essential skills of image and video processing practitioners, and is also an important professional course in intelligent manufacturing, computer science and technology, and other majors. With the rapid development of AI in recent years, there is an increasing demand for talents in two main application fields, natural language processing and digital image processing. In recent years, experts at home and abroad have been exploring the reform of Machine Vision course. For example, Min and Lu focused on the production practice VOLUME 11, 2023 This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 License. For more information, see https://creativecommons.org/licenses/by-nc-nd/4.0/ 32671 L. Wang et al.: Deep Learning-Based Experiment on Forest Wildfire Detection in Machine Vision Course and proposed multimedia teaching and guided interactive teaching. They also suggested that experiments should not only be closely related to classroom teaching, but also in accordance with practical application needs, and can arouse students' interest. Wang et al., aiming at the principle and application of machine vision in the postgraduate curriculum, integrated scientific researches, teaching and practical projects into the classroom. In this way, students can associate the project research with the development of products. Shao et al. designed cocoon sorting in the field of machine vision in order to cultivate intelligent manufacturing talents under the background of new engineering subjects. Han and Liu designed a machine vision experiment platform with multiple modules using Tensorflow and Opencv library to solve the problems of insufficient experiments related to machine vision, unreasonable experimental design and lack of practical data. The reform of Machine Vision course in foreign countries focuses on social awareness education and the reform of teaching methods of basic technology. For example, Sigut et al. believed that the teaching theme of machine vision depends on the use of new technologies. To enable students to better understand the concept, this paper developed an application for Android operating system that can perform real-time presentation of Opencv image processing technology to help students better understand the concepts related to image processing. Cote and Albu advocated integrating the social awareness module into the Machine Vision course, so as to study the social impact of technology and the technology itself. Spurlock and Duvall, in order to expand the educational audience of machine vision,

that is, not limited to postgraduates or doctoral students, increased the development of practical cases in the field of machine vision applications and reduced the derivation of mathematical formulas to better adapt to undergraduate teaching. From the above reform research, it can be found that most teaching methods focus on the combination of theory and practice, while in practice, they focus on how to design experiments that have industrial practicality and can arouse students' interests. Machine Vision is one of the courses that closely link theory with practice. However, at present, most universities' comprehensive experiments for undergraduates/ postgraduates have problems such as outdated design, lack of practicality, and most of them only use traditional machine learning for experiments. Although the research on wildfire detection has made great progress, detection with high accuracy is still a big challenge. In order to solve the above problems, this paper designs an automatic forest wildfire detection framework that can also be used as a comprehensive experiment for Computer Vision course. This framework uses image processing, machine learning, and deep learning technology to achieve automatic detection and annotation of forest wildfire regions, which is a novel way to combine research and teaching. To the best of our knowledge, no previous work has explored the preceding problems to such extent. The main contributions about this paper can be summarized as follows: (1) We propose a novel wildfire image classification algorithm based on Reduce-VGGnet, which can reduce the training parameters of VGGnet and achieve 91.20% in accuracy. (2) We propose a novel wildfire region detection algorithm based on the optimized CNN with the combination of spatial and temporal features. The experimental results on FLAME dataset show the effectiveness of our method. (3) We combine wildfire image classification module and wildfire region detection module to be a comprehensive experiment for Computer Vision course. It is a novel way to effectively combine teaching and scientific research, and incorporates teachers' research into the teaching process.

2. LITERATURE SURVEY:

Face Detection Techniques: A Review

With the marvelous increase in video and image database there is an incredible need of automatic understanding and examination of information by the intelligent systems as manually it is getting to be plainly distant. Face plays a major role in social intercourse for conveying identity and feelings of a person. Human beings have not tremendous ability to identify different faces than machines. So, automatic face detection system plays an important role in face recognition, facial expression recognition, head-pose estimation, human–computer interaction etc. Face detection is a computer technology that determines the location and size of a human face in a digital image. Face detection has been a standout amongst topics in the computer vision literature. This paper presents a comprehensive survey of various techniques explored for face detection in digital images. Different challenges and applications of face detection are also presented in this paper. At the end, different standard databases for face detection are also given with their features. Furthermore, we organize special discussions on the practical aspects towards the development of a robust face detection system and conclude this paper with several promising directions for future research.

Wildfire detection using transfer learning on augmented datasets

Wildfire detection is a time-critical application as the difficulty to pinpoint ignition locations in a short time-frame often leads to the escalation of the severity of fire events. This problem has motivated considerable interest from expert systems research to develop accurate early-warning applications and the breakthroughs in deep learning in complex visual understanding tasks open novel research opportunities. However, despite the improvements in performance demonstrated in the current literature, a comprehensive study of the challenges and limitations of this approach is still a gap in the state-of-the-art. To address this issue, the contributions of this work are threefold. First, we overview recent works to identify common difficulties and shortcomings of these approaches, and assess issues related to the quality of the databases. Second, to overcome data limitations, this work proposes a transfer learning approach coupled with data augmentation techniques tested under a tenfold cross-validation scheme. The proposed framework enables leveraging an open-source dataset featuring images from more than 35 real fire events, which unlike video-based works offers higher variability between samples, allowing evaluating the approach in an extensive set of real scenarios. Third, this article presents an in-depth study of the limitations, providing a comprehensive analysis of the patterns causing misclassifications. The key insights gained in this analysis provide relevant takeaways to guide future research towards the implementation of expert systems in decision support systems in firefighting and civil protection operations.

A novel group detection method for finding related Chinese herbs

In past decades, TCM (Traditional Chinese Medicine) has been widely researched through various methods in computer science, but none digs into huge amount of ancient TCM prescriptions and endless digital TCM information to display the compatible and incompatible relationship among herbs. To meet the challenge and to mine the groups of compatible herbs for further drug exploitation, we explore the property of herbal networks and introduce a novel community detection algorithm

concerning both herbal attributes and graph structural factors. First, we calculate the attribute similarity for each paired herbs to construct the herbal graph. Then, a novel community detection algorithm named RWLT (Random Walk & Label Transmission) is proposed to detect herbal groups with near-linear time. The performance of RWLT has been rigorously validated through comparisons with representative methods against randomly created networks, real-world networks and herbal networks. According to the TCM expert, our method is capable of finding groups of Chinese herbs with intensive correlation, and is also able to separate the herbs with mutual incompatibility to be excluded into different communities.

Review of surface defect detection based on machine vision

Steel plays an important role in industry, and the surface defect detection for steel products based on machine vision has been widely used during the last two decades. This paper attempts to review state-of-art of vision-based surface defect inspection technology of steel products by investigating about 170 publications. This review covers the overall aspects of vision-based surface defect inspection for steel products including hardware system, automated vision-based inspection method, existing problems and latest development. The types of steel product surface defects composition of visual inspection system are briefly described, and image acquisition system is introduced as well. The image processing algorithms for surface defect detection of steel products are reviewed, including image pre-processing, region of interest (ROI) detection, image segmentation for ROI, feature extraction and selection and defect classification. The important problems such as small sample and real time of steel surface defect detection are discussed. Finally, the challenge and development trend of steel surface defect detection are prospected.

Review on application of machine vision in modern automobile manufacturing

As the development of computer and machine vision technology, the rapid, accurate and intelligent characteristics of computer vision technology are widely used in the field of industrial detection. The three main applications of machine vision are measurement, guidance and inspection. The visual measurement technology can ensure the qualified products of the factory by measuring the key dimensions, surface quality and assembly effect of the product. The visual guidance technology can significantly improve manufacturing efficiency and body assembly quality by guiding the machine to complete automatic handling, optimum matching assembly and precise drilling. The visual inspection technology can monitor the stability of the body manufacturing process, and can also be used to ensure the integrity and traceability of the product to reduce the cost of manufacturing. Predictably, with the performance improvement of the core hardware such as cameras, lenses, computer and the development of software technology such as image processing and deep learning, machine vision technology will play a more important role in all areas in the future and there will be a wider space for development.

OpenCV basics: A mobile application to support the teaching of computer vision concepts

Contribution: Open Source Computer Vision Library (OpenCV) Basics is an application designed with the purpose of facilitating the initiation of industrial engineering students in the field of Computer Vision, making the learning process easier, more dynamic and more direct. To this end, an application has been developed for the Android operating system with which users can make use of a wide variety of algorithms available in the OpenCV library. Background: Teaching topics related to Computer Vision can rely on the use of new technologies such as mobile applications. With this type of support, students can learn concepts that might otherwise be difficult to understand. Intended Outcomes: The objective is to facilitate the assimilation of concepts related to Computer Vision by taking advantage of the camera and the processing power of a mobile device to observe in real time the effects produced on an image by many of the image processing algorithms included in OpenCV. This application is currently available to be downloaded for free through the Google Play Store so that anyone interested in the field of Computer Vision can make use of it. Application Design: The proposed approach introduces students to concepts related to Computer Vision by making use of the developed application, complementing the theoretical contents taught by the teacher with specific examples. Findings: The degree of satisfaction of OpenCV Basics users has been evaluated within the framework of the course advanced robotized systems, taught in the industrial engineering degree at the University of La Laguna.

Exploration on the teaching reform measure for machine learning course system of artificial intelligence specialty

Due to the particularity of the artificial intelligence major and the machine learning courses learned, the traditional course teaching model is not suitable for artificial intelligence major machine learning courses. Based on this background, this article proposes a new system based on machine learning curriculum teaching reform. It mainly includes the reform of curriculum teaching mode, curriculum practice reform, and teaching process reform. In order to verify the effect of the proposed new model on the teaching quality of machine learning courses, this article also proposes an evaluation method based on intelligent technology. Firstly, the feasibility of evaluation based on intelligent technology is described. Secondly, it lists the application details of the existing teaching evaluation based on intelligent

technology. Finally, a novel teaching quality evaluation system based on intelligent technology is proposed. The system collects student facial expression data and uses classification algorithms to make classification decisions on the data. The result of the decision can give feedback on the quality of classroom teaching. The comparison of experiments based on different intelligent technologies shows that the teaching quality evaluation system proposed in this article is feasible and effective.

Connections of climate change and variability to large and extreme forest fires in Southeast Australia

The 2019/20 Black Summer bushfire disaster in southeast Australia was unprecedented: the extensive area of forest burnt, the radiative power of the fires, and the extraordinary number of fires that developed into extreme pyroconvective events were all unmatched in the historical record. Australia's hottest and driest year on record, 2019, was characterised by exceptionally dry fuel loads that primed the landscape to burn when exposed to dangerous fire weather and ignition. The combination of climate variability and long-term climate trends generated the climate extremes experienced in 2019, and the compounding effects of two or more modes of climate variability in their fire-promoting phases (as occurred in 2019) has historically increased the chances of large forest fires occurring in southeast Australia. Palaeoclimate evidence also demonstrates that fire-promoting phases of tropical Pacific and Indian ocean variability are now unusually frequent compared with natural variability in pre-industrial times. Indicators of forest fire danger in southeast Australia have already emerged outside of the range of historical experience, suggesting that projections made more than a decade ago that increases in climate-driven fire risk would be detectable by 2020, have indeed eventuated. The multiple climate change contributors to fire risk in southeast Australia, as well as the observed non-linear escalation of fire extent and intensity, raise the likelihood that fire events may continue to rapidly intensify in the future. Improving local and national adaptation measures while also pursuing ambitious global climate change mitigation efforts would provide the best strategy for limiting further increases in fire risk in southeast Australia.

3. SYSTEM ANALYSIS

3.1 Existing System

In Existing system, using VGG16 algorithm to predict forest fire and this fire causes huge financial loss for any country so timely detection of such fire can reduce cost. Manual monitoring is not efficient and some machine and deep learning algorithms prediction accuracy is not accurate while detecting fire in real time.

.2 PROPOSED SYSTEM

In proposed system, using tradition VGG16 as based classifier but as extension we have utilized VGG19 and then we found VGG19 is giving high accuracy compare to VGG16 as based classifier. After adding spatial and temporal features propose Reduce-VGGNet got more than 97% accuracy. Propose algorithm consists of two models such as Fire classification and region-based annotation to put bounding boxes across detected fire.

SOFTWARE REQIREMENTS:

System Atributes:

1. Filename
2. dataset
3. X, Y, mse, X_train, X_test, y_train, y_test
4. **NON-FUNCTIONAL REQUIREMENT:**
5. **Usability:** Usability is a quality attribute that assesses how easy user interfaces are to use. The word "usability" also refers to methods for improving ease-of-use during the design process.(how it was handle entire project easy)
6. **Security:** the quality or state of being secure: such as. a : freedom from danger : safety. b : freedom from fear or anxiety. c : freedom from the prospect of being laid off job security.
7. **Readability:** Readability is the ease with which a reader can understand a written text.
8. **Performance**: the execution of an action. : something accomplished : deed, feat. : the fulfillment of a claim, promise, or request : implementation. 3. : the action of representing a character in a play.
9. **Availability**: the quality or state of being available trying to improve the availability of affordable housing. 2 : an available person or thing.
10. **Scalability**: Scalability is the measure of a system's ability to increase or decrease in performance and cost in response to changes in application and system processing demands.

HARDWARE REQUIREMENTS:

- Processor - Intel i3(min)
- Speed - 1.1 GHz
- RAM - 4GB(min)
- Hard Disk - 500 GB

SOFTWARE REQUIREMENTS:

- Operating System - Windows10(min)
- Programming Language - Python with Jupiter notebook

4-SYSTEM DESIGN

ACTIVITY DIAGRAM:

Activity diagram is another important diagram in UML to describe dynamic aspects of the system. It is basically a flow chart to represent the flow form one activity to another activity. The activity can be described as an operation of the system. So the

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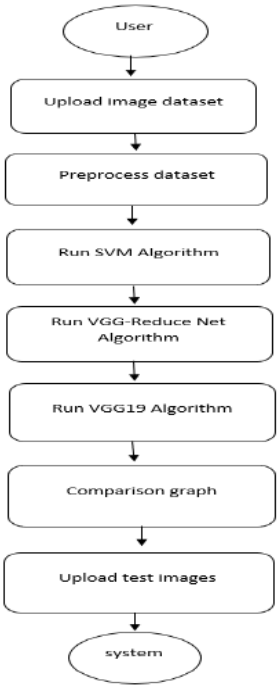
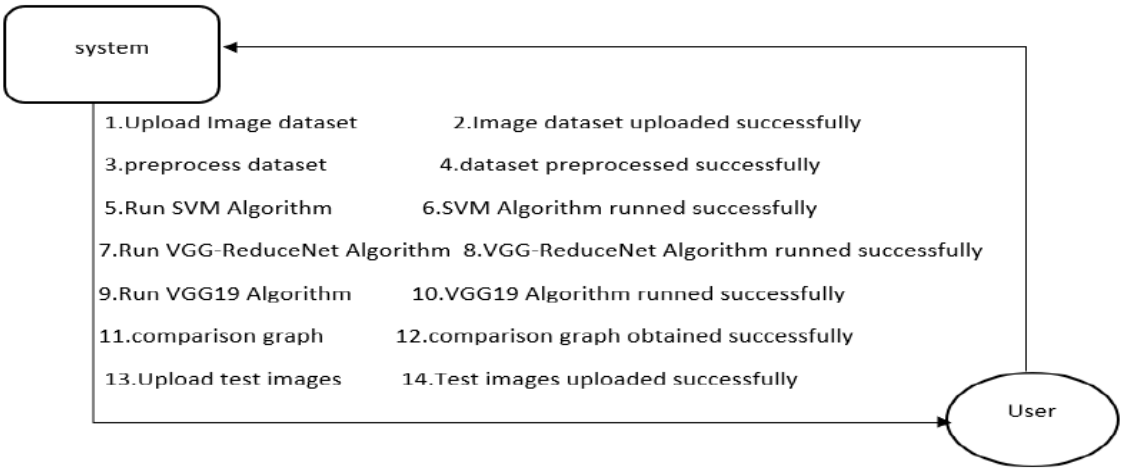
control flow is drawn from one operation to another. This flow can be sequential, branched or concurrent



Data flow:

Data flow diagrams illustrate how data is processed by a system in terms of inputs and outputs. Data flow diagrams can be used to provide a clear representation of any business function. The technique starts with an overall picture of the business and continues by analyzing each of the functional areas of interest. This analysis can be carried out in precisely the level of detail required. The technique exploits a method called top-down expansion to conduct the analysis in a targeted way.

As the name suggests, Data Flow Diagram (DFD) is an illustration that explicates the passage of information in a process. A DFD can be easily drawn using simple symbols. Additionally, complicated processes can be easily automated by creating DFDs using easy-to-use, free downloadable diagramming tools. A DFD is a model for constructing and analyzing information processes. DFD illustrates the flow of information in a process depending upon the inputs and outputs. A DFD can also be referred to as a Process Model. A DFD demonstrates business or technical process with the support of the outside data saved, plus the data flowing from the process to another and the end results.



5. IMPLEMETATION

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5.1 Python

Python is a general-purpose language. It has wide range of applications from Web development (like: Django and Bottle), scientific and mathematical computing (Orange, SymPy, NumPy) to desktop graphical user Interfaces (Pygame, Panda3D). The syntax of the language is clean and length of the code is relatively short. It's fun to work in Python because it allows you to think about the problem rather than focusing on the syntax.

History of Python:

Python is a fairly old language created by Guido Van Rossum. The design began in the late 1980s and was first released in February 1991.

Why Python was created?

In late 1980s, Guido Van Rossum was working on the Amoeba distributed operating system group. He wanted to use an interpreted language like ABC (ABC has simple easy-to-understand syntax) that could access the Amoeba system calls. So, he decided to create a language that was extensible. This led to design of a new language which was later named Python.

Why the name Python?

No. It wasn't named after a dangerous snake. Rossum was fan of a comedy series from late seventies. The name "Python" was adopted from the same series "Monty Python's Flying Circus".

Features of Python:

A simple language which is easier to learn

Python has a very simple and elegant syntax. It's much easier to read and write Python programs compared to other languages like: C++, Java, C#. Python makes programming fun and allows you to focus on the solution rather than syntax.

If you are a newbie, it's a great choice to start your journey with Python.

Free and open-source

You can freely use and distribute Python, even for commercial use. Not only can you use and distribute software's written in it, you can even make changes to the Python's source code.

Python has a large community constantly improving it in each iteration.

Portability

You can move Python programs from one platform to another, and run it without any changes.

It runs seamlessly on almost all platforms including Windows, Mac OS X and Linux.

Extensible and Embeddable

Suppose an application requires high performance. You can easily combine pieces of C/C++ or other languages with Python code.

This will give your application high performance as well as scripting capabilities which other languages may not provide out of the box.

A high-level, interpreted language

Unlike C/C++, you don't have to worry about daunting tasks like memory management, garbage collection and so on.

Likewise, when you run Python code, it automatically converts your code to the language your computer understands. You don't need to worry about any lower-level operations.

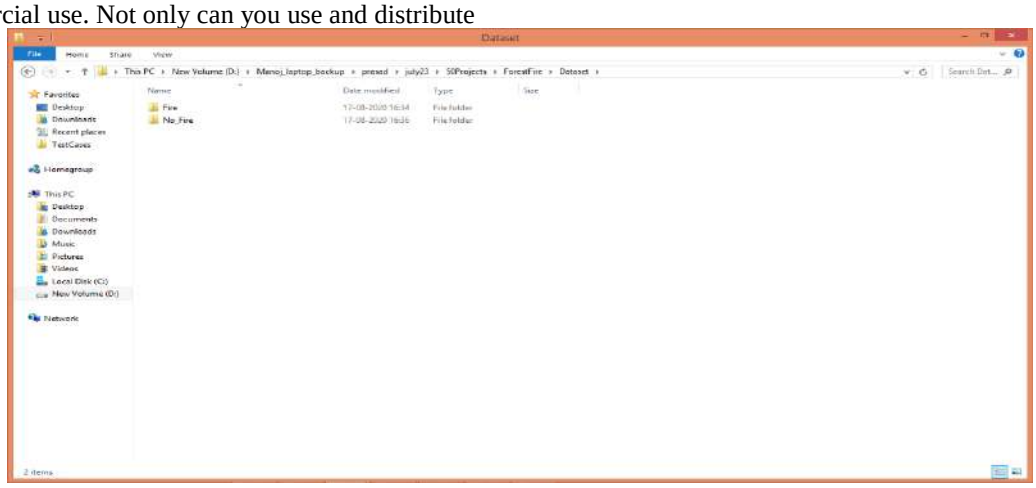
Large standard libraries to solve common tasks

Python has a number of standard libraries which makes life of a programmer much easier since you don't have to write all the code yourself. For example: Need to connect MySQL database on a Web server? You can use MySQL dB library using import MySQL db.

Standard libraries in Python are well tested and used by hundreds of people. So, you can be sure that it won't break your application.

6-SCREENSHOTS:

To train all algorithms author has used FLAMES dataset which consists of 'Fire and NO-Fire images' and below screen showing dataset details



In above dataset folder we have two folders and just go inside any folder to view images.

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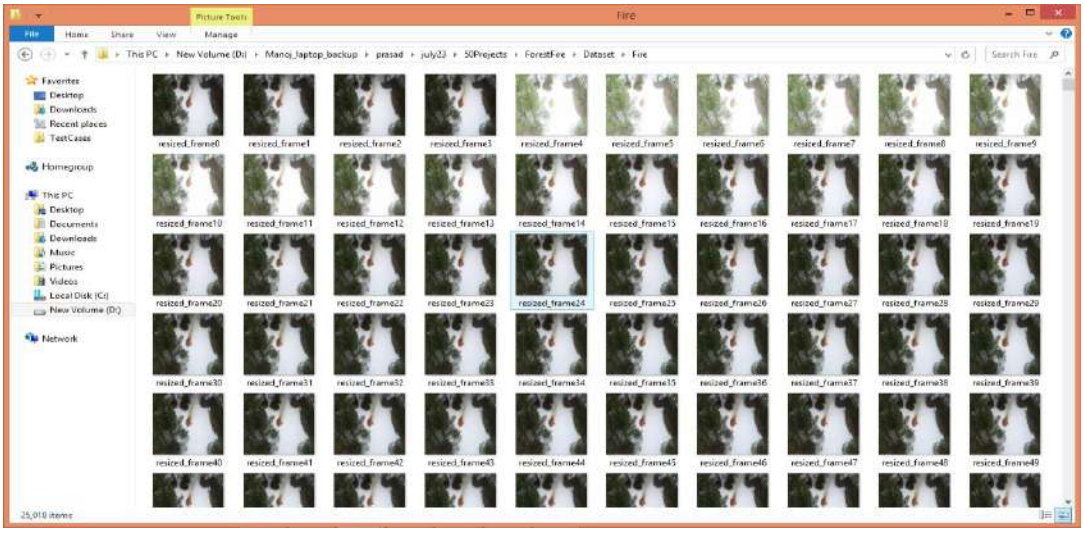
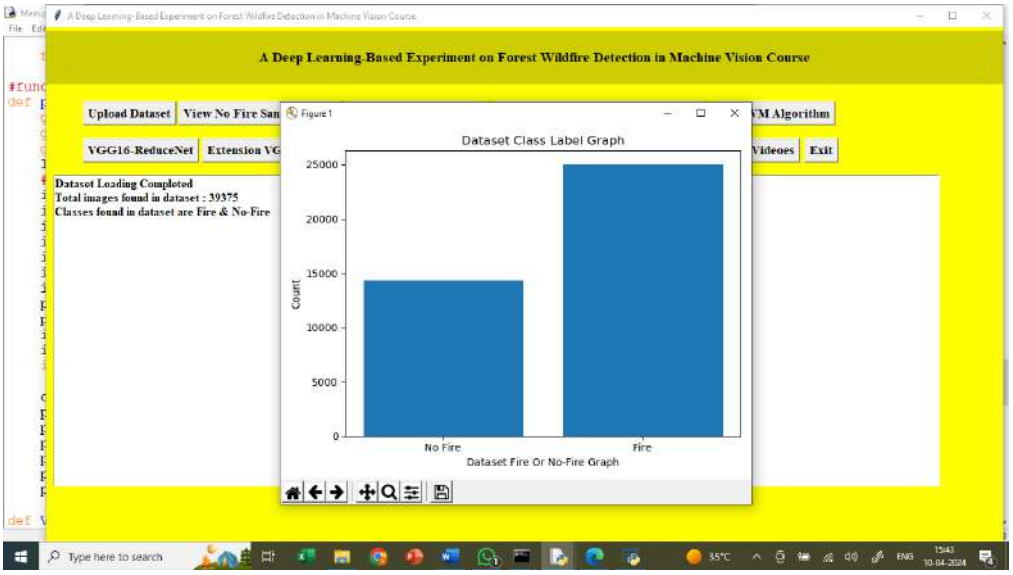
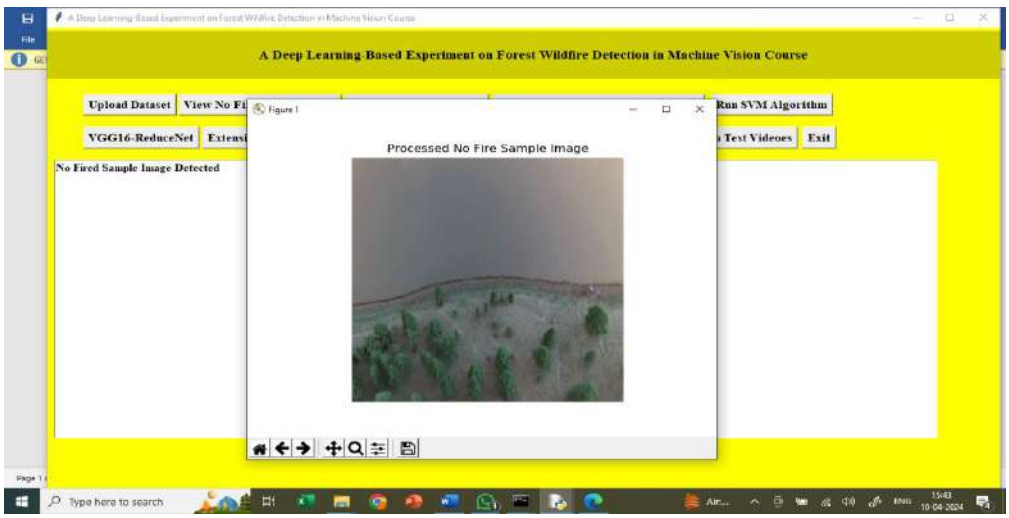


In above screen we can see images with fire so by using above images we will train and test all algorithms.



In above screen in blue colour text displaying total images loaded and in graph x-axis represents type of images as Fire or No-Fire and y-axis represents count.



In above screen displaying processed images from dataset as Fire and NO Fire

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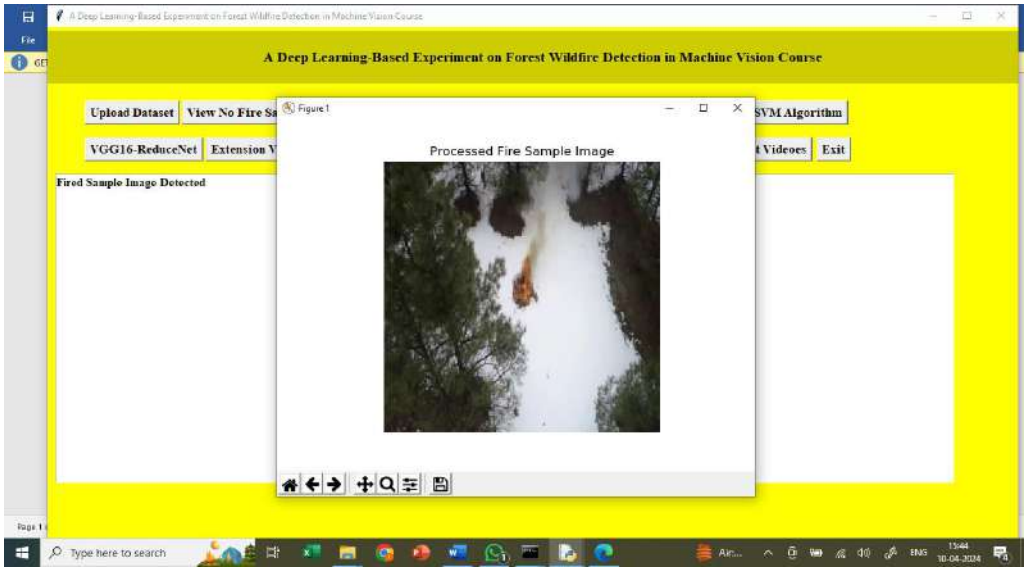
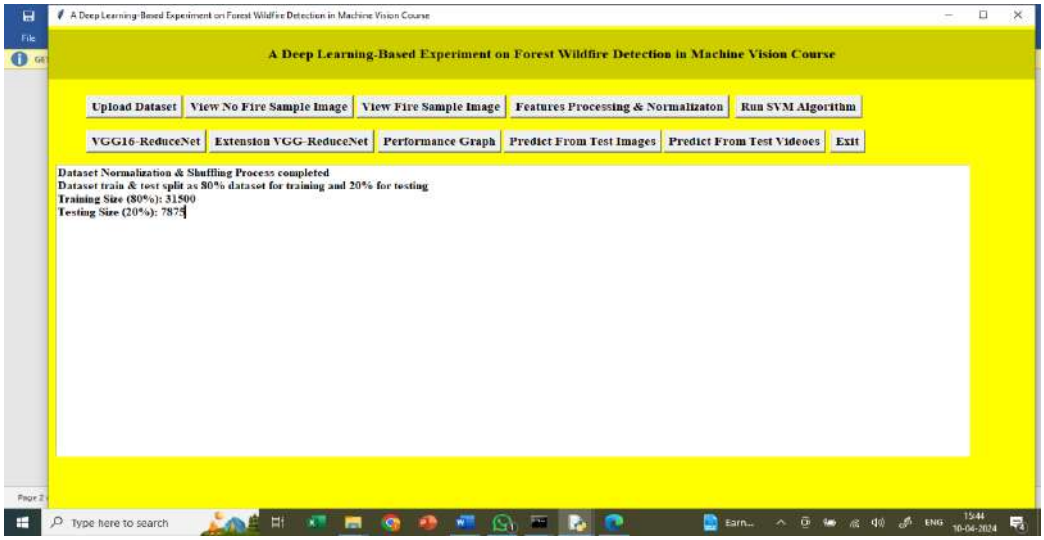
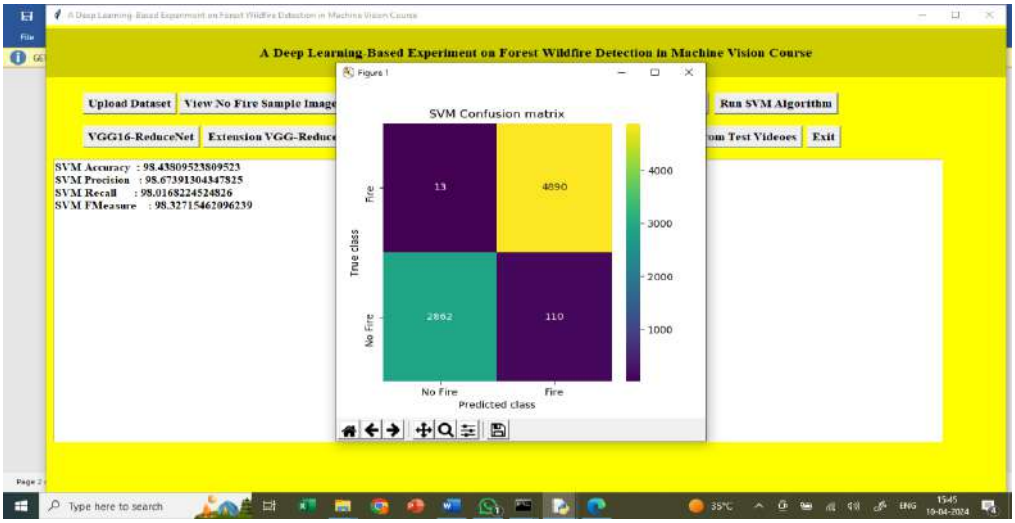


In above screen displaying processed images from dataset as Fire and NO Fire



In above screen we are normalizing, shuffling and splitting dataset into train and test where application using 80% dataset images for training and 20% for testing



In above screen we are training SVM on train data and then evaluating its performance on test data and then SVM got 98% accuracy. In confusion matrix graph x-axis represents Predicted Labels and y-axis represents True Labels

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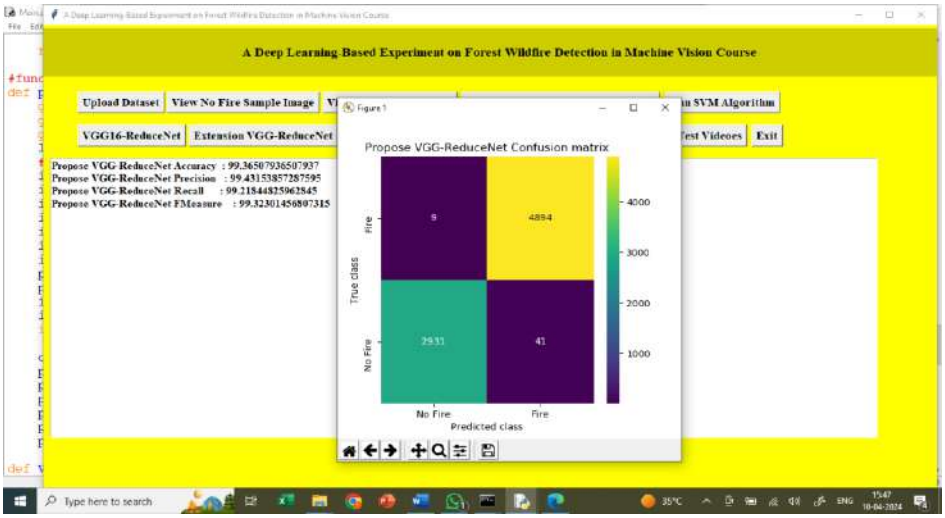
where blue boxes represents incorrect prediction count which are very few and yellow and light green boxes represents correct prediction count.



In above screen we are defining VGG16 as based classifier and then forming new model called VGG-REDUCENET by adding layers to extract Temporal and spatial features and In above screen with propose VGGREDUCENET we got 99.35% accuracy and we can see other metrics also

7-CONCLUSION:

As an interdisciplinary course, Machine Vision combines AI and digital image processing methods. This paper develops a comprehensive experiment on forest wildfire detection that organically integrates digital image processing, machine learning and deep learning technologies. With the rapid development of computer technology and the popularity of cameras, machine vision technology based on artificial intelligence (AI) and digital image processing has been applied to increasing fields, such as face detection , wildfire detection, object measurement and surface defect detection. As an interdisciplinary course, Machine Vision combines AI and digital image processing. With the development of AI, machine vision can replace human beings with intelligent programs for some automated operations and measurements. A complete machine vision system includes a camera and an image processing device. The associate editor coordinating the review of this manuscript and approving it for publication was Senthil Kumar . The camera firstly obtains the images, then we can recognize the target object through the computer's visual recognition algorithm, and finally the image processing device can output the target recognition result through the terminal. At present, machine vision has become one of the essential skills of image and video processing practitioners, and is also an important professional course in intelligent manufacturing, computer science and technology, and other majors. With the rapid development of AI in recent years, there is an increasing demand for talents in two main application fields, natural language processing and digital image processing.

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