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ANOMALY DETECTION IN OBJECTS FROM REMOTELY SENSED IMAGES: AN OVERVIEW WITH REFERENCE TO INDIAN KNOWLEDGE SYSTEM

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Abstract: The term anomaly detection refers to methods and procedures that help in seeking the differences in the sample data that deviate from generally expected patterns. Depending on the availability of data labels, the types of abnormalities, and the applications, many anomaly detection models are developed. This study aims to give a well-organized and thorough review of anomaly detection research. We think it will aid in a superior thoughtful of the various areas in which study has been conducted on this issue, as well as how approaches created in one field can be utilized in domains where they were not originally intended. We've divided the anomaly detection research methodologies into distinct categories. We describe the fundamental anomaly detection approach, as well as its modifications and important assumptions, for distinguishing between normal and abnormal behavior in each category. In addition, we highlight the merits and limits of each category, as well as examine the computational complexity of the approaches in real-world application areas. Deep learning can be enhanced by integrating insights from the Indian Knowledge System, which includes ancient texts like the Vedas, Upanishads, and various philosophical and scientific treatises. By incorporating concepts such as holistic thinking, consciousness, and the interconnectedness of all things, deep learning algorithms may gain a more nuanced understanding of complex systems and patterns. Additionally, principles from disciplines like Ayurveda, yoga, and Jyotish (Vedic astrology) could inspire novel approaches to optimization, adaptation, and self-learning within deep learning frameworks. Integrating these insights could lead to more culturally inclusive and globally relevant AI systems.Finally, we discuss research gaps and limitations encountered when using deep anomaly detection algorithms to solve real-world problems

Index Terms – Anomaly detection, Unsupervised Anomaly Detection, Semi-supervised Anomaly Detection, SupervisedAnomaly Detection, deep learning, Ayurveda, Yoga, Indian Knowledge System.

I. INTRODUCTION

Anomaly detection is a serious subject that has been widely researched across a wide range of research disciplines and application domains. First, this paper offers a systematic and complete review of research methodologies in image anomaly detection. In addition, it analyzes the efficiency of these anomaly detection approaches across a variety of application areas. Although the majority of the strategies for identifying these are similar, their importance and application may vary. We use the nomenclature proposed by authors in [1] in this study and describe each of the tasks as follows:

i. Detection of Anomalies: Anomaly detection may be described as the problem of recognizing samples obtained from any distribution other than P+, if the distribution of normal examples is denoted by P+. A zebra is an aberration, for instance, if we express P+ as the distribution of horses.

ii. Outlier Detection: An outlier is a sample from P+ with a low probability. A Falabella is an anomaly among horse breeds in the case of horse detection. A Falabella represents outlier breed of horse.

iii. Detection of Novelty: A novelty is a sample taken from a new area of a non-stationary distribution of normal samples P+. During the training phase, it is typical for the network to not encounter its counterpart. In the horse detection job, for example, a new breed of horse is considered a novelty.

iv. Out-of-Distribution (OOD) Detection: The purpose of out-of-distribution (OOD) detection is to find samples that do not fit into any of the training set classes. This issue, also known as "open category detection" [2], is frequently expressed as a supervised learning problem in which we have labelled data from K classes during training. During the inference phase, we regard all K classes as normal samples and try to figure out if a sample isn't from one of them. Recent research has demonstrated that utilizing Softmax probabilities to calculate the anomaly scores and training a supervised classifier on K classes can produce state- of-the-art performance in the OOD detection challenge [3]. Page 3/24 Using a classifier trained on an animal dataset to recognize samples from other datasets, such as flowers, is an example of the OOD detection challenge. According to Data Labels Availability It is critical to consider the availability of labels while constructing an algorithm. We may separate AD algorithms into three settings based on label availability [4] as shown in figure 2:

a. Unsupervised Anomaly Detection: We assume that only unlabeled data is available for training the model in this context, whichis perhaps the most prevalent in anomaly detection [5], [6].

b. Semi-supervised Anomaly Detection: We assume that the training dataset is partially labelled and contains both labelled and unlabeled samples in this case. Semi-supervised algorithms are useful in situations when annotating the entire dataset is prohibitively expensive. This environment is especially common in the anomaly detection sector since there is frequently both labelled and unlabeled data, yet labelling the data often takes specialist knowledge, and abnormalities can be costly in some circumstances, such as industrial and biomedical applications.

c. Supervised Anomaly Detection: We presume that the dataset is completely labelled in supervised anomaly detection. When abnormalities can be easily documented, supervised algorithms are preferable [7]–[10]. It's critical to distinguish between supervised anomaly detection and binary classification tasks at this stage. If normal and abnormal data are supplied during the training phase, the problem can be phrased as a supervised binary classification problem, and the job will no longer be an anomaly detection task.

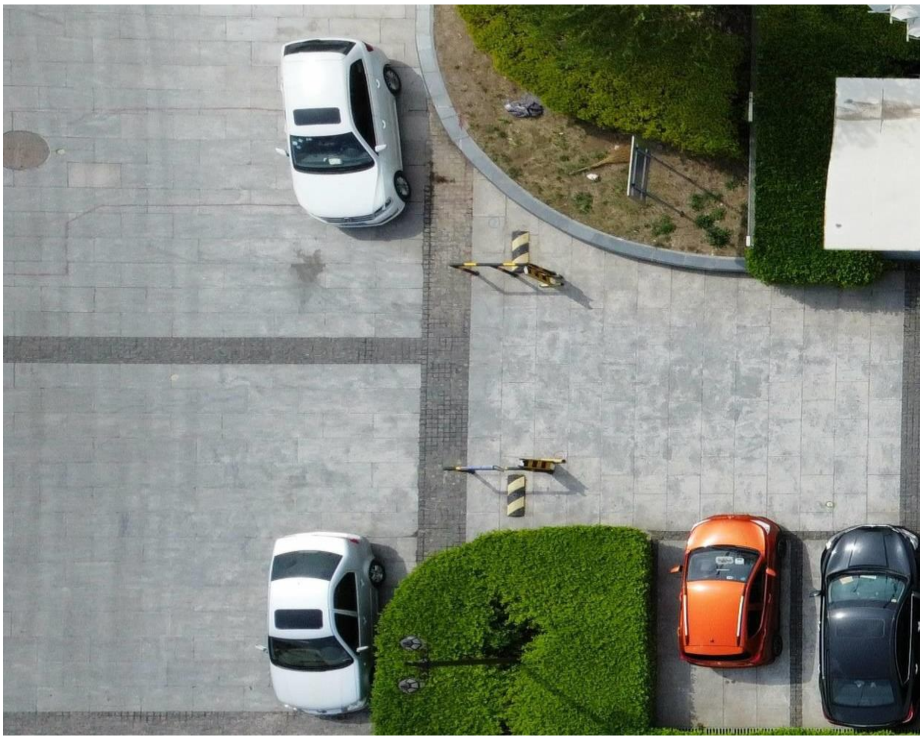

Fig.1 ariel images of cars

II. RELATED WORK

A literature survey involves reviewing relevant research papers, articles, and publications to understand the current state of knowledge in a specific field. In the context of anomaly detection in satellite images using deep learning, the survey encompasses a range of studies that explore methodologies, techniques, and applications. Here is a brief literature survey highlighting key research in this area. Anomaly detection (AD) is a vast area of research given its diverse applications [11], [12]. The fixed threshold method is currently the most commonly used satellite anomaly detection method in engineering [13], but due to the large number of telemetry parameters and the influences of unknown factors such as the space environment, it is difficult to set an appropriate threshold for each parameter, and it is difficult to guarantee the rationality of the detection threshold [14]. This survey provides an overview of anomaly detection techniques, focusing on hyperspectral imagery. While not exclusively deep learning, it discusses traditional methods and sets the stage for understanding how deep learning approaches can be integrated for improved anomaly detection [15]. This paper introduces a method combining background subtraction and deep learning for detecting anomalies in agricultural fields using satellite imagery. The study demonstrates the effectiveness of deep learning in identifying anomalies and obstacles in dynamic environments [16]. This review focuses on the application of deep learning in satellite image analysis for disaster monitoring. It covers various disaster types and discusses the role of deep learning in anomaly detection within the context of natural disasters [17]. This study explores a deep learning approach for earthquake damage detection in satellite images. It discusses the use of convolutional neural networks (CNNs) for identifying anomalies related to seismic events [18].

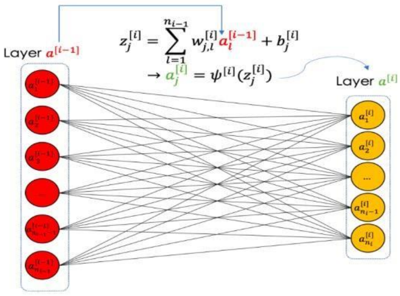

Fig. 2 mathematical model and the structure of convolutional neural network

The paper explores the fusion of deep learning and handcrafted features for anomaly detection in hyper-spectral imagery. It discusses the combination of convolutional neural networks with traditional techniques for improved detection and localization [19]. This paper presents DeepSat, a deep learning framework for satellite imagery analysis. While not exclusively focused on anomaly detection, it lays the groundwork for understanding the application of deep learning in satellite image classification and analysis [20]. This comprehensive review provides insights into the application and applications of deep learning in remote sensing, covering various aspects, including anomaly detection in satellite imagery. It discusses challenges and opportunities in the field [21].

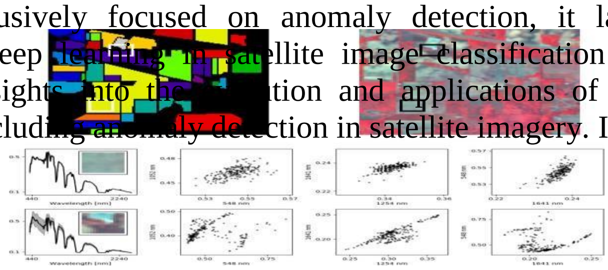

Fig. 3 Image detection and analysis

III. Methodology

i. Deep Learning and Indian Knowledge System

a. Holistic Thinking: The Indian philosophical tradition often emphasizes the interconnectedness of all things and the importance of understanding systems as wholes rather than just the sum of their parts. This holistic perspective can inspire deep learning models to consider the broader context and relationships within data, leading to more comprehensive and nuanced understanding.

b. Consciousness and Self-awareness:

Concepts of consciousness and self-awareness found in Indian philosophies such as Vedanta and Yoga can inspire new approaches to designing AI systems that exhibit self-awareness or mimic aspects of consciousness. This could lead to AI models that better understand their own functioning and adapt more effectively to changing circumstances.

c. Interdisciplinary Insights: The Indian Knowledge System encompasses a wide range of disciplines, including not only philosophy but also medicine (Ayurveda), mathematics (Vedic mathematics), and astronomy (Jyotish). Drawing on insights from these diverse fields can inspire novel approaches to problem-solving, optimization, and pattern recognition within deep learning algorithms.

d. Cultural Inclusivity: By integrating diverse cultural perspectives into deep learning, we can create AI systems that are more inclusive and reflective of global diversity. Incorporating insights from the Indian Knowledge System alongside other cultural traditions can help mitigate biases and foster a deeper understanding of diverse perspectives.

IV. Limitations

The difficulty in choosing a suitable neural network structure for a specific task, trained neural networks are not interpretable models or black boxes, so the logical interpretation of the described patterns is almost impossible. Another limitationis that the neural networks have ability to process only numeric variables.

V. Conclusion

The methods and procedures used in the detection of anomaly in remotely sensed sample images seek the differences that deviate from the original expected patterns. There are many methods for the anomaly detection using artificial intelligence like the machine learning that makes with 3 types learning Supervised, semi-supervised and unsupervised learning. Furthermore, the deep learning has many methods for anomaly detection using neural networks like Convolutional Neural Network and YOLO (You Only Look Once). The deep learning methods give more precise and accurate results as compared machine learning methods. Overall, integrating insights from the Indian Knowledge System into deep learning has the potential to enrich AI research and development by providing new perspectives, approaches, and principles for building more intelligent and culturally inclusive systems.

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