Object Detection on Satellite Image: A Systematic Literature Review

by Mufti Leriansyah

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Abstract— **Object detection from satellite imagery is essential in various applications such as urban planning, environmental monitoring and disaster management. With the increasing availability of high-resolution satellite imagery, the need for accurate and efficient object detection algorithms is also increasing. In recent years, deep learning-based methods have significantly improved object detection accuracy. This paper presents a systematic literature introduction (SLR) of objects from satellite imagery to identify and extract relevant and essential data for the study. The analysed papers show that object detection in satellite imagery is widely implemented for ship, aircraft, building, and fire detection. SLR on object detection from satellite imagery can provide valuable insights into the current state of knowledge, identify areas for future research, and inform the development of more effective and efficient object detection methods for object detection**

Keywords— ***Obeject detection, satellite imagery, deep learning, systematic literature review.***

I. INTRODUCTION

Object detection in optical remote sensing imagery involves recognizing objects' predicted location and class labels in satellite or aerial imagery. Object detection is essential in various remote sensing applications, such as urban planning, environmental monitoring, and other civil and military applications [1].

In recent years, more and more methods have been developed to detect geospatial objects in optical remote sensing images, such as airplanes, ships, and storage containers [10]. However, despite the diversity of object scales, the methods developed for detecting objects from high-resolution and large-scale remote sensing images remain a big challenge because the orientation, shape, distribution, and illumination conditions, as well as complex backgrounds, make it difficult to detect objects from high-resolution remote sensing images [2].

The abundance of literature and methods in this field makes it challenging to determine the most effective way for a particular application with the most accurate and effective methods. To address this problem, Systematic Literature Reviews (SLR) have become a popular method for summarizing state-of-the-art in a particular research area. This paper presents a method for detecting Systematic Literature Reviews (SLR) objects from satellite imagery. We aim to take a comprehensive and rigorous approach to identify, evaluate, and synthesize existing research studies in a given field.

Systematic Literature Reviews (SLR) on object detection from satellite imagery can provide a comprehensive overview of state-of-the-art evaluation techniques, data sets, and metrics used in this field. This review can also identify objects in existing research and provide insights for further research directions.

To get complete results in preparing this SLR, we searched for several references published in popular journal databases such as IEEE Xplorer Limited from 2019 to 2022. Further explanation of this paper will be explained as follows. We describe the research method in section II. We offer the results and analysis in Part III. The last section of our paper is the conclusion.

II. METHOD

A. Review Method

In this paper, we make review with several studies on object detection with satellite images by following SLR guidelines, including the stages of planning, implementing, and reporting [3]

At the planning stage, we sought information about object detection to narrow our research scope by defining our research questions, literature sources, search strategy, selection criteria, and data analysis. In compiling this SLR, we made steps such as searching, collecting, selecting, extracting, and compiling a literature summary.

B. Defining Research Questions

The following research questions serve as a guide for keeping awareness going:

RQ.1 What are the Research Objects Detected in Satellite Imagery?

RQ.2 What are the benefits of object detection in satellite imagery?

RQ.3 What methods are used in object detection in satellite imagery?

We evaluate every part of the chosen article in order to respond to these queries.

C. Search Process

In the process of preparing the SLR, we searched for literature online using the IEEE Explore site. Search terms used were "satellite imagery, image detection, object detection & computer vision", associated with this research and perform various combinations thereof.

D. Eligibilty Criteria

In the search process, we filter using the following criteria:

1. We limit our search to publications from the previous four years, thus we choose 2019 to 2022 as the range.
2. We exclude review paper surveys and solely conference and journal submissions.

E. Analysis of Data

After getting the selected papers we analyze the contents of each paper. From the results of the analysis, we took the topics of services, benefits, technology used, and the level of accuracy.

III. RESULTS AND ANALYSIS

A total of 6653 papers were generated from IEEE Explore before filtering. The results change to 2369 papers after being filtered down to the last four years of publication. After that, other papers were excluded because they were review papers and the remaining 2328 papers. After a comprehensive review, 25 were selected for inclusion in this systematic review. The results are shown in Table 2

TABLE I
NUMBER OF SELECTED PAPERS TROUGH THE SELECTION PROCESS

Search Results	Filtered Results	Acquired Papers	Selected Papers
6653	2328	79	22

A. Publication Year

Figure 1 displays the distribution of selected papers by year of publication. As shown, each paper included was released during the previous four years.
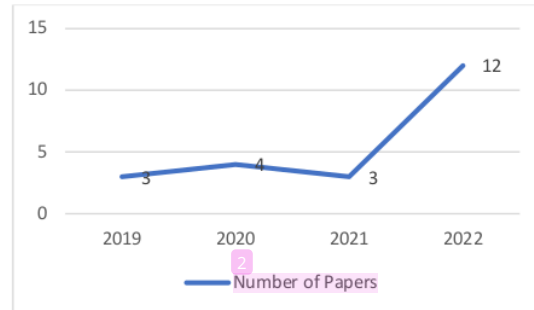

Fig. 1 Publication year of the selected papers

The graph shows that in 2022 there has been a sharp increase in object detection research on satellite imagery, this shows that a lot of research related to object detection on satellite imagery was carried out in 2022.

B. Research Objects Detected in Satellite Imagery

Figure 2 paper distribution based on the services discussed.
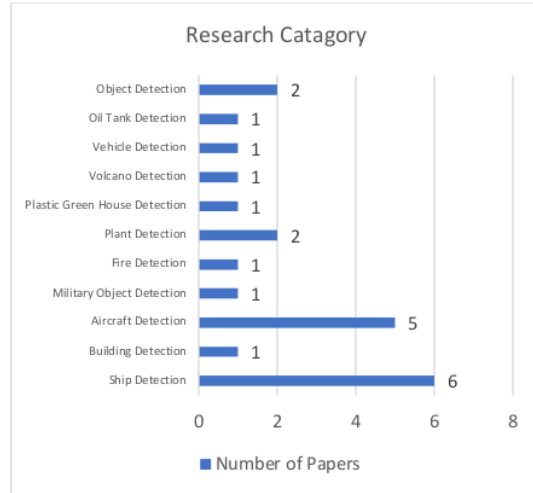

Fig. 2 Research Objects Detected in Satellite Imagery

In the papers we analyzed, 11 different challenge categories were identified. This figure shows that ship detection is the most researched problem. This indicates that research related to this field is still extensive and developing until now due to the need for applications in maritime surveillance, safety, security, and monitoring of the maritime environment.

After ship detection, the research that has been carried out is aircraft detection. Using satellite imagery on aircraft to realize real-time airport flight monitoring can better analyze and improve flight plans. In addition, the plane at the airport will often be mobilized for military activities, so it is essential to analyze the battlefield situation and formulate a military strategy

C. Benefits of Object Detection on Satellite Imagery

Object detection on satellite images can identify changes in urban areas over time, which can help urban planning and development. For example, detecting changes in the number of buildings[5], roads, and parks can provide valuable information for urban planners [10].

Ergio Povoli et al. said An essential part of the technology used in object detection is maritime surveillance applications, i.e. ship detection using synthetic aperture radar images, which aims to monitor the environment, security, and safety at sea [7]. Ricardo Zalukhu et al. also argue that detecting ship's goods may support maritime security enforcement measures such as regulating sea traffic monitoring and combating illegal fishing. [15]

Apart from ships, object detection using satellite imagery can also be used for ship detection, as was done by [4], [11], and [15] in their research discussing the importance of detecting aircraft objects using satellite imagery[6],[7], and[8]. one of them for military purposes [12].

Object detection on satellite imagery can assist in identifying and monitoring disaster-prone areas, which can help predict and prevent disasters and manage them when

they occur. As an example in the study of Yang et al. also commonly used for the detection of hotspots during forest fires [13]

Object detection on satellite imagery can help monitor crop growth and yield. Several studies have been carried out, such as the detection of coconut trees [24], and other studies have also been carried out to detect oil palm trees [23]. This information can be used to optimize farming practices and increase agricultural productivity.

Overall, object detection on satellite imagery can provide valuable insights and information across various fields, leading to more efficient and effective decision-making.

D. Object Detection Method on Satellite Imagery

TABLE II
OBEJCT DETECTION METHOD ON SATELLITE IMAGERY

No	Methode	Reference
1	Resnet	[9]
2	Contario	[10]
3	FCN	[17]
4	CNN	[5][12][13][14]
5	RCNN	[11][18][20
6	Faster-RCNN	[23][24]
6	Yolo-V5	[6] [7][8][15][19]
7	Yolo-V4	[1]
8	Yolo-V3	[4][10][22]
9	Yolo	[21]

The results obtained in the collected and analysed papers were to get nine methods. Several methods that are rarely used, such as Contario, FCN, and Resnet, are still being used in recent years.

The methods often used in object detection on satellite imagery in the paper under study are YOLO-v5, which produces high accuracy in each of their studies. The Yolo method of all existing versions is still popular because the speed, accuracy, and multi-class detection are superior.

The graph shows that the Yolo algorithm in each version always experiences an increase in detection, so it is still the leading solution in using methods for object detection in satellite imagery.

Apart from the Yolo method, the CNN method is number two on the chart this time, where this method is also widely used to detect objects in satellite imagery. This method is also a good choice for researching object detection.

IV. CONCLUSION

Object detection from satellite imagery provides essential benefits in various fields and requires combining techniques and algorithms for optimal results. The SLRs presented in this paper provide an overview of current state-of-the-art methods and highlight the need for further research in deep learning and computer vision for satellite image detection. The research gap that needs to be addressed is increasing accuracy in object detection. Further research is required to develop more accurate and efficient techniques for detecting small and complex objects. Our findings can benefit researchers and practitioners interested in image detection from satellite imagery. They can assist in developing new techniques that can overcome challenges and improve object detection accuracy from satellite imagery.

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