A Comparative Analysis of Post-Disaster Analysis Using Image Processing Techniques

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Abstract. Post-disaster recovery is a multifaceted system essential for rebuilding communities and infrastructure. Despite its importance, many limitations obstruct powerful recuperation, main to tremendous loss of life and monetary assets. This paper synthesizes varied approaches in the direction of sustainable restoration, highlighting the increasing reliance on technology for disaster management. Image processing strategies, pivotal in addressing these demanding situations, are reviewed across studies. Those strategies range from SLIC segmentation and Random forest classification to advanced deep learning models together with U-net and YOLOv8, machine learning algorithms like SVM, and image category methodologies along with bi-temporal analysis. Comparative evaluation reveals that those strategies presents promising consequences, with accuracies starting from 75% to over 94%. The paper gives a framework for understanding the role of various image processing strategies in improving disaster control strategies, emphasizing their implications for future studies and application.

Keyword: Disasters, post-disasters, recovery, machine learning techniques, classifications.

1. Introduction

The process of rebuilding public services, accommodation, and infrastructure following a
disaster is known as "post-disaster recovery." This is a complicated procedure that needs the involvement of the public and commercial sectors. However, during a natural disaster (see Fig.1), environmental recovery is sometimes not given priority. Effective post-disaster recovery is neglected, resulting in large losses of assets, human life, and financial resources, even in cases where post-disaster recovery operations are adopted. The way that decision-makers approach sustainable post-disaster recovery is changing to one that is systematic. There isn't an exhaustive compilation of obstacles to successful rehabilitation following a disaster, though. The identification and analysis of these obstacles should be the main priorities in order to develop an integrated approach. To guarantee a smooth and effective recovery process, independent investigations of the obstacles to post-disaster recovery for all sorts of disaster are required [1]. Housing is essential to ensuring the continued existence of displaced victims, however there is a dearth of thorough knowledge regarding post-disaster temporary residential structures (PDTRB). The Sphere Handbook 2018, a humanitarian standard, sets priorities for basic necessities based on logistics and supply chain management. There are four stages to housing, which are emergency sheltering, interim residences, and permanent residence. Accommodation is the most important component of post-disaster relief and building. Because of outside factors, refugees frequently spend years or even months in shelters for emergencies or transitional shelters [2]. The research in [3] examines how people decide whether to evacuate during unexpected emergencies, with an emphasis on the variables that affect how people react to man-made disasters. The study appears on the variables affecting the response to the explosion that occurred at the Port of Beirut in Lebanon in August 2020 the usage of the protective movement decision model (PADM). by using contrasting it with analogous studies carried out in North America and the Asia-Pacific vicinity, the studies tries to offer an intensive understanding of the factors using evacuation decisions in developing countries. The investigation emphasizes how susceptible the people of Lebanon are to natural calamities. Poor agricultural populations in developing nations are particularly vulnerable to climate variability, which can result in lost crop income and asset destruction [4].
Household well-being is greatly impacted by disasters in all social and economic categories. Households' capability to implement suitable preventive measures and have access to resources determines their ability to deal with and recover from disasters. The ability to cope without permanently depleting resources is essential for long-term survival, and no means of coping can completely protect against shocks from disasters.

2. Image Processing for Disaster Analysis

Although diseases and disasters are becoming more unpredictable, this has increased reliability on technology while also seriously disrupting lives, businesses, and services. In order to reduce socioeconomic loss, it is imperative that data trends and warning indicators for natural disasters be studied, as well as any potential hazards. The study in [5] examines recent studies on data analysis, the forecasting of natural disasters, and the use of technological advances for management tactics, with a focus on Industry 4.0 and the use of cognitive computing. The main goal is to investigate research ideas that leverage data mining and big data to detect and observe patterns, allowing predictive analysis to foresee future calamities. Tropical cyclones are widespread in coastal regions across the globe, and their efficient management necessitates a range of methodologies and information.

Guidelines for choosing the best datasets and processing methods for tropical storm disaster management are provided by the study in [6]. It covers how to analyze impacts, recovering from them, assess risks, and predict risks using remote sensing and spatial analytic techniques. For cyclone effect assessment and recovery, the study suggests post-classification change identification by object-based image analysis employing optical imaging up to 30 m resolution. For the purpose of assessing cyclone risk, the analytical hierarchy process-based spatial multi-criteria decision-making technique is recommended.

Mapping flood areas is essential for disaster management since it gives authorities access to up-to-date information on areas that have been flooded. This problem can be met with the aid of Spaceborn Synthetic Aperture Radar (SAR) technology, which gathers vital data from vast, difficult-to-reach areas. However, because high altitude regions, shadows, runways, and extensive road networks all have comparable reflectance, mapping flood-related information in SAR photos requires careful consideration. To overcome these obstacles and increase mapping accuracy, researchers have used image processing techniques and image categorization methods. In order to provide new investigators interested in SAR image-based flood area mapping approaches with references, the study in [7] attempts to comprehend and document important SAR image-based flood area mapping models from the 1990s to 2015. Massive volumes of records are regularly shared by way of victims of disasters on social media platforms, as these channels have become the primary means of informing the general population and emergency responders (ERs). However within minutes of a calamity, these systems are overrun with huge amounts of data, lots of which are unnecessary and duplicated. Because of this, it's miles tough for ERs to interpret the facts and come to choices. Processing and interpreting large facts from social media related to screw ups remains a hard assignment, despite technical developments [8]. The concept of "citizen as sensors" has come of age over the past ten years, as statistics on natural catastrophes is being collected increasingly more through using Volunteered Geographic information (VGI). The advancement of deep learning methods in computer vision and the processing of natural languages has made it possible to extract more data from social media, such as flood water levels and the extent of building damage. This data
has been combined with information from other sources, such as networked sensors and remote sensing, in recent research to provide thorough and in-depth information on catastrophic events [9]. Massive destruction of human lives, environmental resources, and economies are brought about by natural calamities. Big data can assist in extracting geospatial information for efficient disaster response. Examples of this include social media posts, GPS traces, and satellite photos. Disaster response systems, however, need to integrate data with varying processing requirements from many sources [10]. Disaster prevention researchers have difficulties when determining which processing framework is best for a given big data set in order to accomplish a certain objective.

3. Comparative Framework

The work proposed in [11] provides an approach that does away with the requirement for human geo-referencing in the detection of damage caused by natural catastrophes using post-event imagery. The technique extracts 62 features by segmenting images into uniform superpixels using simple linear iterative clustering (SLIC). At 90.4% accuracy, the Random Forest classifier is quite accurate. The research employs aerial photographs from the 2011 Japan earthquake and tsunami as well as the 2011 Christchurch earthquake to identify structural damage. Taking into account six levels of destruction, the method generates an evaluation map that shows the degree of damage in each superpixel. The National Disaster Response Force (NDRF) and other disaster rescue organizations must use high-quality aerial photos taken by UAVs, or unmanned aerial vehicles, to create post-disaster strategies for recovering. Construction, roads, and obstacles can be identified and classified using the two deep learning models and image processing technique proposed in [12], which uses an aerial image as input and output. The DeepGlobe Road Extraction dataset was utilized to detect roads, while the xView2 dataset was employed for training. The road identification model employs the U-Net architecture with a final intersecting over union score of 0.95892, and the construction recognition and damage classification approach uses the YOLOv8 architecture with an average accuracy and precision score of 58.3. Urban regions are greatly threatened by floods, necessitating the use of effective management techniques such locating flood-prone areas, quickly identifying impacted areas, charting rescue routes, and setting up logistics. Modern technologies such as machine learning and image recognition can be used to improve flood management. Using machine learning (SVM) and image processing (Landmark), the research in [13] provides a unique technique to detect flood-prone regions using a series of images. An image is classified as flooded or not based on landmarks, machine learning algorithms, and classification of landmarks. The 90% accuracy stage confirmed via the records emphasizes the significance of this image-based flood detection technology.

The research investigation in [14] makes use of high-decision remote sensing images received after a disaster to offer a knowledge-based approach for detecting and comparing road damage. Using traits which include road brightness, deviation from common, rectangularity, and element ratio, the approach creates a information version by using extracting the road centerline based totally on predetermined avenue seed points. After a disaster, the information model extracts the roadways and makes use of the version to identify broken ones. Additionally counseled are harm assessment indications and the related damage grading widespread. Three days following the earthquake on can also 15, 2008, a WorldView-1 image over Wenchuan, China, is used to evaluate the effectiveness of the method. The effects display the usefulness of the technique in detecting and assessing
avenue damage, with the manufacturer's accuracy (PA) reaching about 90% and the consumer's accuracy (UA) reaching approximately 85%. The study in [15] investigates how to evaluate the impact of disasters using satellite imagery and deep learning algorithms. Convolutional Neural Networks are used to semantically separate topographical elements, such as highways, using pre- and post-disaster satellite pictures in order to identify affected regions. However, because topographical characteristics are sparsely distributed in rural settings, this strategy is less useful there. A bitemporal image classification method is suggested as a solution to this problem. When tested against a rural scene affected by South Asian Monsoon flooding in 2017, the flooded road extraction strategy registered an accuracy of 84.5% with an F1-Score of 0.675, while the bitemporal image categorization method reported an accuracy of 94%.

Employing MATLAB functions such as improvement, edge, thinning, and label associated elements, in [16] proposes a method for identifying the level of damage from inputs. Forty Geo Eye photos, twenty pre and twenty post, were used to test the approach, which was found to identify 50% of thinning images as destroyed. Additionally, 60% of thinned destructed photos, 50% of edged images, and 80% of edged destructed images were identified as destructed by the approach. 70% of relevant extents were recognized by the approach, according to its 70% recognition rate. It was discovered that the methodology's efficiency was roughly 75%. It is crucial to think about the possibilities for future study as the exploratory age of research progresses. The study in [17] suggests employing convolutional neural networks (CNN) for automatic natural disaster identification for floods and landslides. CNN is resilient, capable of gathering disaster characteristics sufficiently, and able to overcome operator error or misidentification. There are two stages to a neural network: training and testing. Employing aerial photos from Google Earth Aerial Images, training data patches are made with an emphasis on Thailand and Japan. CNN is used to extract disaster region regions from 50,000 patches that make up the training dataset for both catastrophes. The system's accuracy in detecting both disasters was approximately 85%.

Table 1: Comparison of different techniques used in detection of post disaster

<table>
<thead>
<tr>
<th>Study</th>
<th>Approach</th>
<th>Techniques Used</th>
<th>Dataset Used</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>[12]</td>
<td>Road and construction detection</td>
<td>U-Net and YOLOv8 deep learning models</td>
<td>DeepGlobe Road, xView2 datasets</td>
<td>0.95892 (IoU for roads), 58.3% (YOLOv8)</td>
</tr>
<tr>
<td>[13]</td>
<td>Flood area detection</td>
<td>Machine learning (SVM), image processing (Landmark)</td>
<td>Not specified</td>
<td>90%</td>
</tr>
<tr>
<td>[14]</td>
<td>Road damage detection and evaluation</td>
<td>Knowledge model, feature extraction</td>
<td>WorldView-1 image over Wenchuan, China</td>
<td>PA: ~90%, UA: ~85%</td>
</tr>
<tr>
<td>[15]</td>
<td>Disaster impact evaluation</td>
<td>CNN, bitemporal image classification</td>
<td>South Asian Monsoon flooding scene</td>
<td>84.5% (single scene), 94% (bitemporal)</td>
</tr>
<tr>
<td>[16]</td>
<td>Damage level identification</td>
<td>MATLAB image processing functions</td>
<td>Geo Eye images</td>
<td>Overall efficiency: ~75%</td>
</tr>
</tbody>
</table>
Table 1 showcases a sequence of research focusing on disaster evaluation using image processing, highlighting numerous approaches and techniques like SLIC segmentation, deep learning models which includes U-net and YOLOv8, and machine learning algorithms like SVM. Each study makes use of distinct datasets, including aerial and satellite photos from natural disasters throughout the globe, and reports various levels of accuracy, from 75% to over 94%. Those comparative insights replicate the evolving landscape of post-disaster evaluation and the increasing reliance on advanced image processing strategies for effective disaster management.

![Accuracy (% of Different Techniques used)](image)

**Fig.2:** Accuracy of Image Processing Techniques in Disaster Management

The bar chart in Fig. 2 presents the accuracy percentages of various image processing techniques applied in disaster management. It compares the efficacies of Random forest, YOLOv8, SVM, knowledge model, CNN, and Bitemporal evaluation. The Random forest and knowledge model techniques exhibit the highest accuracy, almost touching the 90% mark, indicating their robustness in analyzing disaster-related images. In contrast, YOLOv8 shows a significantly lower accuracy, simply above 50%, suggesting it is able to have limitations in this context. SVM and CNN both present with strong, albeit barely lower accuracies, indicating their application within the field. The Bitemporal approach also demonstrates excessive accuracy, corresponding to the main strategies, underscoring its effectiveness in detecting modifications over time caused by disasters.

4. **Methodologies in Image Processing for Disaster Analysis**

To mitigate the adverse consequences, disaster management entails identifying and classifying natural disasters. Numerous disasters can be identified with the aid of advanced technologies as shown in Fig. 3 such as machine and deep learning, satellite photos, and human observation. These approaches have the potential to increase preparedness and resilience while underscoring the significance of continuing research and advancing
existing strategies for disaster management in the future [18]. In order to reduce losses in terms of people, money, and morality in humanitarian supply chain activities, a new model has been devised. Using machine learning techniques, the model takes into account patient risk levels, the size of the disaster, the distances between relief facilities, and the number of rescuers who are needed and available. The accuracy and originality of the methodology in securing priority for injured patients and assessing risk levels are illustrated through a case study conducted in Tehran. The results confirm that the model works as intended [19].

Gathering data on disaster events is essential to efficient disaster response, which includes evaluating lifeline infrastructure. Data is gathered using a variety of instruments, but their uses, levels of accuracy, and resource requirements differ. Examples of these include satellites, drone imagery, and structural strain gauges. The study in [20] examines post-disaster damage assessment tools, with a particular emphasis on buildings and lifeline networks under different risk scenarios. The research points out weaknesses in the current methods of gathering data and makes recommendations for enhancements, like coordinating data collecting, taking advantage of regional dependencies, and providing comprehensive tool characteristics in metadata [21]. The building and lifeline infrastructure damage assessment is being comprehensively analyzed for the first time using this systematic examination.

Building identification and categorization are steps in the automated damage assessment process. Bounding boxes are drawn around each building in a picture, pre- and post-disaster photographs are extracted, and damage is determined using a classification algorithm. In order to determine whether the building was damaged, the model analyzes changes between two photos using a neural network. Standard methods for augmenting data are combined with histogram equalization to account for variations in color and lighting [21]. The scarcity of high-resolution satellite pictures and current damage estimates limits the training data set. Humanitarian organizations create the labels by hand, and Google Earth Engine is
used to spatially link them with satellite photos. With the help of [22-24], a data-driven optimization approach to diagnosing and treating anxiety and depression in students will be developed. The technique makes use of a rule-based dispatching system, ensemble learning classifier, hyperparameter optimization, sentiment analysis, and data pretreatment. This approach is a dependable post-disaster strategy that combines three approaches to treat mental health concerns among pupils. According to the study, 44% of depressive and anxious pupils were identified by the suggested method, compared to 7–15% by traditional methods [25]. This creative method is a post-disaster astute and dependable way to deal with pupils' mental health concerns. Building damage has significantly increased as a result of hurricane severity, according to reconnaissance reports [26]. In order to speed up recovery, this results in building components being diverted to landfills and demolition. There are environmental consequences to traditional practices, such as greenhouse gas emissions and land contamination. The best accuracy of 66.7% was achieved in predicting building reusability using a gradient-boosting regression model [27]. The greatest feature priority score is assigned to roof structure damage, indicating that reduced damage to the roof's framework may improve the building's potential for reuse following a hurricane. In order to reclaim salvaged construction materials and minimize culturally significant structures, a circular economy resilience framework is developed. Deconstruction is a techniques, homogeneity, fewer hazardous materials, and simpler building component disassembly are some of the solutions. Additionally, the framework lessens the environmental impact of rehabilitation following a disaster, fostering resource efficiency and climate [28]. The complexity of each technology and the requirement for compatible data integration make it difficult to integrate technology into post-disaster architecture recovery [29]. Water Management System (WMS), Building Defect Analysis (DL), and Building Information Modeling (BIM) integration can be highly beneficial to post-disaster building recovery [30-33]. With deep learning for damage evaluation, WMS for longevity variables, and BIM serving as the element-level data foundation, a sustainable combined system takes sustainability into account when rehabilitating broken elements. Metadata for particular element types can be accessed with a BIM Level of Development (LOD) of 300 [34]. The work uses remote sensing data from Guizhou, China, taken both before and after the disaster to offer a method for dynamically visualizing landslides [35]. It takes into account slope gradients, water content, rock, and soil when landslide development occurs. By identifying risky locations, the technique enhances catastrophe preparedness and emergency response [36]. For increased accuracy, future studies should incorporate machine learning techniques, real-time meteorological data, and sensors situated on the ground. More efficient risk management and hazard assessment techniques may be influenced by this approach [37].

5. CONCLUSION

The review underscores the important role of image processing in enhancing disaster management and recovery. By evaluating numerous studies, we've highlighted the effectiveness and demanding situations of various strategies, from traditional machine learning to advanced deep learning models. Whilst there are challenges, which includes records availability and model accuracy, the ability for those technology to noticeably aid in subit-catastrophe eventualities is apparent. As technology advances, integrating these image processing techniques could be important for more efficient and effective disaster response strategies.
• Image processing is critical for boosting disaster management and recovery.
• Strategies range from SLIC segmentation and Random woodland to advanced U-net and YOLOv8 models.
• Demanding situations consist of information availability and model accuracy in numerous disaster scenarios.
• Ability for considerable improvements in post-disaster response and planning.
• Future strategies must focus on integrating and refining those technologies for broader application.

References

2. Qin, Mingyuan, Bee Teng Chew, Yat Huang Yau, Zhen Yang, Xiaofei Han, Li Chang, Yiqiao Liu, and Song Pan. "Characteristic analysis and improvement methods of the indoor thermal environment in post-disaster temporary residential buildings: A systematic review." Building and Environment (2023): 110198.
26. Kumar, K. U., Babu, P., Basavapoornima, C., Praveena, R., Rani, D. S., & Jayasankar,


