

Web-Based Anomaly Detection for Smart Urban Living: Drone Photography and Videography

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Abstract— Smart cities aim to enhance the quality of life for urban dwellers through technological advancements. Machine Learning (ML) plays a crucial role in various domains of Smart X, including education, transportation, healthcare, environment, and living. However, integrating ML into daily life poses challenges. This paper presents a web-based ML application prototype that effectively augments the daily quality of life for communities. It specifically explores the advantages of web-based photography-videography-enabled drones for citizen needs and city inspections. The application utilizes ML to detect anomalies and identify normal objects, addressing the common challenge of distinguishing normalcy from abnormality. Examples include assessing the structural integrity of house components, analyzing medical images, and evaluating the quality of fruits or hydroponic plants. The study employs exploratory and experimental methods, utilizing teachable machine learning and the Python-based Streamlit application. Experimental results demonstrate that web-based photo and video analysis expedites the detection of normal and abnormal images and videos, surpassing the limitations of visual examination with the naked eye. This research contributes to advancing ML applications in smart living for urban communities.

Keywords— Anomaly Detection, Smart City, Smart Living, Teachable Machine Learning, Web Photo Recognition, Object Detection, Streamlit

A. INTRODUCTION

In urban environments, the occurrence of normal and abnormal conditions is commonplace. These terms are commonly used to describe the expected and unexpected states or behaviors. When it comes to matters of health, individuals often question the normality of their heart function or express concerns about the possibility of having cancer. X-ray imaging techniques have proven effective in identifying abnormal patterns in the heart or brain. Similarly, it is essential to identify any structural damage in various components of buildings, including walls, roofs, ceilings, and windows. However, human visual perception has inherent limitations, particularly when it comes to observing objects or locations that are physically distant. Fortunately, advancements in science and technology offer promising solutions to address these challenges.

In the realm of Artificial Intelligence, specifically Machine Learning, the term "Anomaly Detection" is used to identify various normal and abnormal conditions [1]–[11]. Previous research has successfully employed deep learning techniques for anomaly detection, including the detection of cancer anomalies. For instance, the brain-tumor-mri-dataset from Kaggle has been utilized to detect abnormalities in brain tumors, comprising 7023 images obtained from MRI scans categorized into glioma, meningioma, no tumor, and pituitary cases.[12], [13].

Furthermore, AI-based applications have demonstrated the capability to detect unfavorable conditions in different objects, such as damaged fruits [14] [15] [16], metal

surfaces [17], [18] and pipes [19]. By leveraging web-based applications accessible through smartphones urban communities can improve their quality of life by utilizing these tools for shopping or engaging in various fields like construction, industry, agriculture, and medicine.

With the rapid advancement of drone technology, the ability to remotely access and capture observation photos (telemetry) has become a reality. This breakthrough has significant implications for urban communities, as it enables them to monitor and observe previously inaccessible areas from a safe distance. Notably, drones have been deployed for various purposes, such as face detection [20], identifying abnormal fire threats [21], surveillance of surrounding forests [22], monitoring outdoor sports activities [23], [24] assessing traffic conditions overseeing crowds to ensure public safety [1], [25], [26]. These applications underscore the potential of drones in enhancing situational awareness and facilitating efficient decision-making processes.

B. METHODOLOGY/MATERIAL

This research utilizes an exploratory approach, specifically focusing on machine learning modeling such as: Teachable Machine Learning from Google [27] Github and experimental Streamlit with Python, to develop a prototype model based on Internet Protocol (IP) that can be applied to drones. The purpose of this research is to lay the foundation for further investigation, particularly in the context of a dissertation proposal. The findings and insights gained from this study will contribute to the advancement of knowledge and serve as a basis for future research endeavors.

With using the CRISP-DM [5], [28] methodology for research and development, the steps are following:

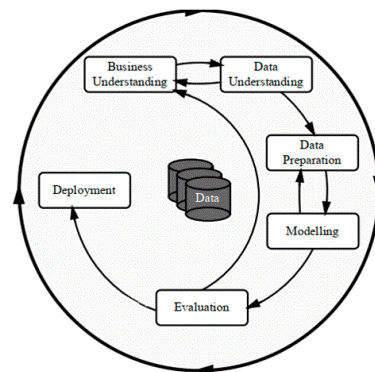


Figure 1: CRISP-DM Diagram [29]

A. Business/Research Understanding

1) Problem Identification

The integration of anomaly detection techniques into daily life processes in smart urban environments is challenging, particularly in terms of web-based accessibility. Traditional methods relying on visual inspection are time-consuming and subjective. This paper aims to address this issue by developing a web-based anomaly detection system using drone photography and videography. The research focuses on identifying abnormal patterns or events in real-time, leveraging machine learning algorithms and the CRISP-DM methodology. By harnessing the power of drones and web-based technologies, the goal is to enhance.

2) Research Objection

The aim of this research is to explore and develop a web-based application integrated with drones to enhance the quality of life for individuals. This includes utilizing the application for anomaly detection through the analysis of photos and videos captured by drones. The research seeks to identify and implement innovative solutions that can

contribute to improving the overall well-being and daily experiences of individuals in urban environments.

3) *Limitation Research*

Since this is preliminary research for further real-world applications using drones, the experiments will only be conducted using a PC and cloud-based systems. The intention is to develop a prototype that can be applied to drones in the future. Therefore, no actual drones will be used in the experiments.

B. Data Understanding

The required data for this research consists of photos and videos that are necessary for inspecting hard-to-reach areas and capturing details that may be difficult for the human eye to perceive. Examples of data include images of damaged building windows, walls, floors, and platforms. The data also includes object detection for identifying humans, animals, trucks, motorcycles, and weapons in restricted areas where access is prohibited. Additionally, the data encompasses the detection of wilted leaves in plants and the verification of the authenticity of specific products. In this case there two input type of data: First from uploaded image and second from video receiving by webcam in real time.

C. Data Preparation

Cleanse, preprocess, and transform data for analysis and modeling. Address missing values, outliers, and perform feature engineering. For this prototype, all Data sources coding are stored in Davy Hermanus repositories Github [30] but all images are uploaded directly to Teachable Machine With Google [27] as could be seen in figure 2.

D. Modeling

In this foundational research, machine learning techniques and experimental Streamlit with Python are employed to develop the prototype model. The process involves selecting appropriate algorithms, training and evaluating the models, and fine-tuning the parameters. Initially, the model development utilizes Google's Teachable Machine to detect anomalies, particularly focusing on wall damage captured through long-distance photographs.

In the second scenario, object detection using Yolov8, is utilized to identify anomalies in various locations that require observation.

1) *Photography for Building Anomalies*

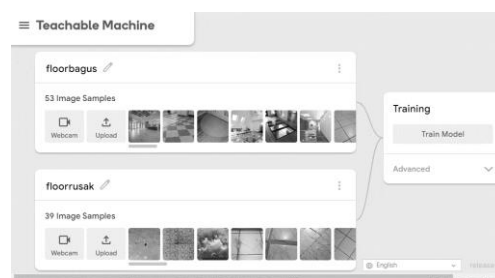


Figure 2. The modeling data consists of images for the recognition model of Good Wall or Bad Wall, developed using Teachable Machine with Google. [27]

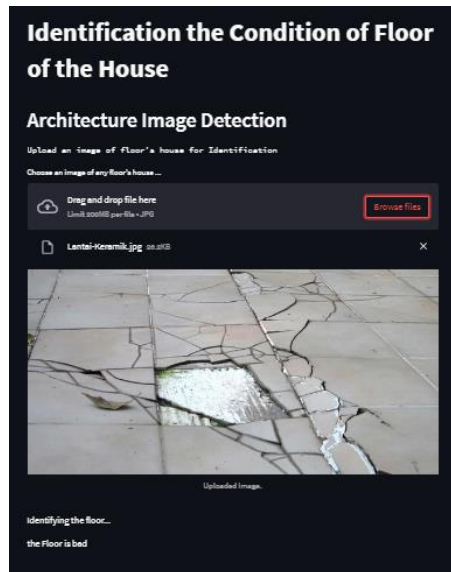


Figure 3. The result of detecting abnormal or damaged floor objects captured from <https://davyrh-floor-app-dgh9po.streamlit.app/>
 Others objects are Ceiling Anomaly (<https://davyrh-ceiling-app-tkfhon.streamlit.app/>) (Foundation Anomaly (<https://davyrh-foundation-app-vw6uan.streamlit.app/>), Glass Anomaly (<https://davyrh-glass-app-bd4tbk.streamlit.app/>), Roof Anomaly (<https://davyrh-roof-app-ugjwdm.streamlit.app/>) and Wall Anomaly (<https://davyrh-wall-app-vrxpdv.streamlit.app/>)

1) Object Detection with video using external webcam.

In this scenario, the output showcases the visual representation of all the detected objects from the webcam utilizing the Python Streamlit Library. This display can be observed in Figure 4, providing an overview of the interface. The menu offers various options such as image selection, webcam, video, and even streaming models from sources like RTSP or YouTube. The captured image demonstrates the successful detection of objects through the utilization of a web browser on a laptop, leveraging the webcam functionality.



Figure 4. Object Detection using Streamlit on Web Browser captured form Local Computer Webcam

E. Evaluation: Assess prototype model performance using appropriate metrics. Validate effectiveness and compare against benchmarks or existing methods.

G. Deployment: Prepare this prototype model for integration with drones and IP infrastructure. Ensure effective utilization in real-world scenarios.

I. Documentation: Document research process, including steps, data preprocessing, modeling approaches, evaluation results, and challenges faced.

J. Communication: Present findings, insights, and implications clearly. Share outcomes with stakeholders, academic communities, or industry professionals through papers, presentations, or other channels.

Iteration: Reflect on research process and outcomes. Identify areas for improvement and consider further iterations or refinements to enhance the prototype model or explore additional research questions.

III ANALYSIS THE RESULT

There are two categories of detection: one is through precise photo analysis to determine normal or abnormal conditions, and the other is through direct detection using a webcam or online camera. The first category is recommended to use high-precision camera photos. Sufficient datasets are required to differentiate between normal and abnormal conditions. For example, even slight cracks in walls can be categorized as damaged. These results were obtained using images from a PC. For further research, it can be determined which areas are suitable for using smartphone models that can be used by the public, and which areas are not feasible without the use of drones equipped with high-resolution cameras. Examples include detecting damages on roofs or walls of tall buildings or detecting plants in mountains or valleys.

The second category involves real-time object detection using videos. Abnormal conditions are observed based on live video observations, where objects considered normal will appear in blue segmentation, while objects detected as dangerous will appear in red segmentation. In drone applications, this can be achieved by providing a dataset with predefined categories.

For future recommendations, it is advisable to conduct further research that utilizes drones for Situational Awareness in urban areas, aimed at enhancing security and comfort for urban communities. Several potential schemes could be considered, such as:

Drone-based Surveillance: Utilizing drones equipped with high-resolution cameras for real-time monitoring of urban areas, identifying potential security threats and suspicious activities.

Traffic Management: Deploying drones to monitor traffic conditions, detect congestion areas, and provide real-time updates to optimize traffic flow and improve transportation efficiency.

Environmental Monitoring: Employing drones to monitor air quality, noise levels, and other environmental parameters to assess the overall well-being and livability of urban environments.

Disaster Management: Utilizing drones for rapid assessment of disaster-affected areas, identifying hazards, and aiding in search and rescue operations.

Infrastructure Inspection: Conducting regular inspections of critical infrastructure, such as bridges, towers, and power lines, using drones to identify structural anomalies or damages for timely maintenance and repairs.

These schemes can contribute to the development of a smart and safe urban environment, where drones play a crucial role in providing real-time data and insights for decision-making and proactive management. Further research in these areas can significantly contribute to the advancement of Situational Awareness and improve the overall quality of life in urban communities.

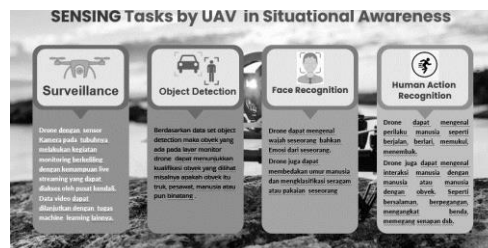




Figure 5. Sense, Understanding and Action Tasks for Situational Awareness with Collaboration of Multi Drones.

Situational Awareness[31] is crucial for effective decision-making and response in various domains, including security, disaster management, and urban planning. To enhance Situational Awareness, the collaboration of multiple drones can provide comprehensive and real-time data from different perspectives. This approach can be achieved through the following stages: sense, understand, and act.

Further research in this area can focus on optimizing the coordination and communication protocols among drones, developing efficient algorithms for data fusion and analysis, and integrating AI-based decision-making mechanisms. By enhancing the Sense, Understand, and Action capabilities of multi-drone systems, Situational Awareness can be significantly improved, leading to more effective responses and better management of urban scenarios.

IV. CONCLUSION

In conclusion, this paper has explored the application of web-based anomaly detection utilizing drone photography and videography for smart urban living. The integration of drone technology and web-based applications offers significant potential in enhancing the quality of life and safety of urban communities.

Through the utilization of drone photography and videography, anomalies in various aspects of urban life can be detected and monitored. The use of high-resolution cameras mounted on drones enables detailed inspection of buildings, such as identifying damaged walls, floors, or other structural issues. This provides valuable information for maintenance and safety purposes, ensuring a safer living environment for urban residents.

Additionally, the integration of web-based applications allows for remote access and monitoring of drone-captured data and images. This enables real-time anomaly detection, facilitating timely responses and interventions. By utilizing machine learning techniques and advanced image recognition algorithms, anomalies can be automatically identified and classified, improving the efficiency and accuracy of the detection process.

The results of this research demonstrate the effectiveness of web-based anomaly detection using drone photography and videography in enhancing smart urban living. By providing real-time monitoring and detection capabilities, urban communities can enjoy improved safety and convenience.

As a recommendation for future research, further exploration can be done to enhance the capabilities of web-based anomaly detection systems. This includes the development of

more advanced machine learning models and algorithms to improve the accuracy and efficiency of anomaly detection. Additionally, the integration of other data sources, such as IoT devices or social media data, can provide a more comprehensive understanding of urban anomalies.

In conclusion, web-based anomaly detection using drone photography and videography holds great potential for improving smart urban living. By leveraging the power of technology and data analysis, urban communities can enjoy a safer and more efficient living environment. Continued research and development in this field will contribute to the advancement of smart cities and the well-being of urban residents.

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