CROWD MONITORING USING DRONE IMAGE ANALYSIS

A Project Report

Submitted in the partial fulfillment for the award of the degree of

BACHELOR OF ENGINEERING

IN

Computer Science (Big Data Analytics)

Submitted by:

Siddharth Singh Bhadouria (20BCS3933)

Under the Supervision of:

Mr. Mahadev Sir

CHANDIGARH UNIVERSITY, GHARUAN, MOHALI - 140413, PUNJAB

May 2023

Acknowledgement

The project work in this report is an outcome of continuous work over a period and drew intellectual support from various sources. I would like to articulate our profound gratitude and indebtedness to those persons who helped me in completion of the project. I take this opportunity to express my sincere thanks and deep gratitude to all those people who extended their wholehearted co-operation and have helped me in completing this project successfully.

I am thankful to my supervisor Mr. Mahadev Sir for assisting me in making the project successful. The project work in this report is an outcome of continuous work over a period and drew intellectual support from various sources.

Siddharth Singh Bhadouria (20BCS3933)

List of Figures

List of Abbreviations

1. SVM - Support Vector Machine
2. HOG – Histogram of Oriented Gradients
3. RGB – Red, Green, Blue
4. UAV - Unmanned Aerial Vehicle
5. ML – Machine Learning
6. DL – Deep Learning

ABSTRACT

Crowd monitoring and analysis has become increasingly used for unmanned aerial vehicle applications. From preventing stampede in high concentration crowds to estimating crowd density and to surveilling crowd movements, crowd monitoring and analysis have long been employed in the past by authorities and regulatory bodies to tackle challenges posed by large crowds. Conventional methods of crowd analysis using static cameras are limited due to their low coverage area and non-flexible perspectives and features. Unmanned aerial vehicles have tremendously increased the quality of images obtained for crowd analysis reasons, relieving the relevant authorities of the venues' inadequacies and of concerns of inaccessible locations and situation. This paper reviews existing literature sources regarding the use of aerial vehicles for crowd monitoring and analysis purposes. Vehicle specifications, onboard sensors, power management, and an analysis algorithm are critically reviewed and discussed. In addition, ethical and privacy issues surrounding the use of this technology are presented.

CONTENTS

INTRODUCTION

1.1 Problem Definition

The problem addressed in this project is the need for effective crowd monitoring and management in various scenarios, including public events, urban areas, and critical infrastructure. Traditional methods of crowd control and monitoring often have limitations in terms of coverage, accuracy, and real-time insights. There is a growing demand for a more comprehensive and efficient approach that can provide accurate crowd data, enable proactive decision-making, and enhance public safety measures.

1.2 Project Overview

The project focuses on developing a crowd monitoring system using drone image analysis to address the challenges associated with traditional crowd control and monitoring methods. By leveraging the capabilities of drones, advanced image analysis algorithms, and data analytics, the project aims to provide an effective solution for crowd monitoring, management, and public safety.

1.3 Project Specifications

- Programming Language – Python
- Libraries & Tools – Histogram of Oriented Gradients
- IDE – VS Code
- Documentation – Microsoft Word

LITERATURE SURVEY

Crowd monitoring is an essential aspect of ensuring public safety, managing events, and optimizing crowd flow in various environments such as stadiums, festivals, protests, and urban areas. Traditional crowd monitoring techniques often rely on manual observations or fixed cameras, which have limitations in terms of coverage, flexibility, and real-time analysis. In recent years, the emergence of drone technology and image analysis algorithms has provided new opportunities for efficient and accurate crowd monitoring. This literature review explores the existing research and developments in crowd monitoring using drone image analysis, highlighting the benefits, challenges, and potential applications of this approach.

2.1 Existing Methods

2.1.1 TensorFlow and Keras:

TensorFlow and Keras are popular deep learning frameworks that offer pre-trained models and tools for object detection and tracking. They provide powerful APIs for implementing state-of-the-art algorithms such as Faster R-CNN, Mask R-CNN, and EfficientDet. These frameworks allow you to leverage the capabilities of deep neural networks for accurate and efficient object detection in drone imagery.

.

2.1.2 PyTorch:

PyTorch is another deep learning framework that is widely used in computer vision tasks. It offers a range of pre-trained models and tools for object detection, including Faster R-CNN, Mask R-CNN, and YOLO. PyTorch provides flexibility and ease of use, allowing you to customize and fine-tune models according to your specific requirements.

2.1.3 Detectron2:

Detectron2 is a high-performance object detection library built on PyTorch. It provides a modular and flexible framework for object detection and instance segmentation. Detectron2 offers a collection of state-of-the-art models and efficient algorithms for crowd monitoring applications. It supports custom dataset handling, model training, and inference.

2.1.4 MMDetection:

MMDetection is an open-source object detection toolbox based on PyTorch. It provides a rich collection of pre-trained models and algorithms for object detection, instance segmentation, and more. MMDetection offers a user-friendly interface, enabling you to quickly set up and train models for crowd monitoring tasks.

These libraries and frameworks offer a wide range of options for object detection and tracking in drone imagery. The choice of library depends on factors such as the specific requirements of your project, the complexity of the detection task, and the level of customization needed.

METHODOLOGY

The methodology for crowd monitoring using drone image analysis involves several steps, including data acquisition, preprocessing, object detection and tracking, and crowd analysis. The following is a comprehensive methodology for this project:

1. **Data Acquisition:**
    - Obtain aerial drone imagery of the target area where crowd monitoring is required.
    - Ensure that the drone is equipped with a high-resolution camera capable of capturing clear and detailed images.
    - Fly the drone over the area of interest and capture images or videos from different angles and heights.
2. **Preprocessing:**
    - Convert the captured images or videos into a suitable format for further analysis.
    - Apply image enhancement techniques such as contrast adjustment, noise reduction, and image stabilization to improve the quality and clarity of the images.
    - Perform georeferencing if necessary to align the images with the corresponding geographic coordinates.
3. **Object Detection:**
    - Utilize an object detection algorithm such as the Histogram of Oriented Gradients (HOG) to detect human subjects in the drone imagery.
    - Implement the selected algorithm using appropriate libraries or frameworks such as OpenCV, TensorFlow, or PyTorch.

- Adjust the algorithm parameters, such as the threshold and minimum box area, to optimize the detection performance based on the characteristics of the crowd and the environment.

4. **Object Tracking:**

- Apply object tracking techniques to track the detected human subjects across consecutive frames.
- Utilize methods such as centroid tracking or Kalman filtering to estimate the position and velocity of the tracked individuals.
- Update the tracking information frame by frame to maintain an accurate count of individuals and their movements.

5. **Crowd Analysis:**

- Analyze the tracked data to extract meaningful crowd information and insights.
- Calculate crowd density, crowd flow patterns, and crowd density variations over time.
- Identify areas of high congestion or potential crowd-related risks.
- Apply crowd behavior analysis techniques to detect anomalies, crowd formations, or unusual behaviors.

6. **Visualization and Reporting:**

- Visualize the analyzed data using graphs, heatmaps, or other visual representations to facilitate interpretation and decision-making.
- Generate reports summarizing the crowd monitoring results, including the total number of individuals, crowd density trends, and key observations.
- Present the findings in a clear and concise manner, using visual aids to effectively communicate the crowd dynamics and any significant findings.

8. **Iterative Improvement:**

- Continuously evaluate and refine the methodology based on feedback and real-world implementation.

- Explore alternative algorithms, techniques, or sensor configurations to improve the accuracy and efficiency of crowd monitoring.
- Incorporate feedback from stakeholders, domain experts, and end-users to enhance the system's capabilities and address specific requirements.
-

By following this methodology, crowd monitoring using drone image analysis can provide valuable insights into crowd behavior, density, and movement patterns. It enables effective crowd management, enhances public safety, and aids in decision-making for various applications, including event management, urban planning, and public security.

LANGUAGES & TOOLS

1. **Python**: Python is a versatile and widely used programming language known for its simplicity and readability. It provides a rich ecosystem of libraries and frameworks that are crucial for implementing crowd monitoring using drone image analysis. In this project, Python serves as the primary language for coding the various functionalities and algorithms.
2. **OpenCV**: OpenCV (Open Source Computer Vision Library) is a popular open-source computer vision library that provides a wide range of functions and tools for image and video analysis. It offers various pre-trained models and algorithms for object detection, tracking, and image processing. OpenCV is extensively used in this project for tasks such as human detection using the Histogram of Oriented Gradients (HOG) algorithm, image preprocessing, and visualization.
3. **TensorFlow and Keras:** TensorFlow and Keras are powerful deep learning frameworks that enable the implementation of complex neural network models. They provide a high-level interface for building, training, and deploying deep learning models. In this project, TensorFlow and Keras can be employed for advanced crowd analysis tasks, such as crowd behavior prediction or anomaly detection using deep learning algorithms.
4. **NumPy and SciPy**: NumPy (Numerical Python) and SciPy (Scientific Python) are fundamental libraries for scientific computing and data analysis

in Python. They provide efficient data structures, mathematical functions, and numerical algorithms. NumPy is used for handling and manipulating multidimensional arrays of image data, while SciPy can be utilized for statistical analysis or signal processing tasks related to crowd monitoring.

5. **Matplotlib and Seaborn**: Matplotlib and Seaborn are data visualization libraries in Python that enable the creation of various types of plots, charts, and graphs. They are essential for visualizing the crowd monitoring results, such as crowd density trends, movement patterns, and heatmaps. Matplotlib provides a flexible and comprehensive set of plotting functions, while Seaborn offers enhanced statistical visualization capabilities.
6. **Jupyter Notebook:** Jupyter Notebook is an interactive computing environment that allows the creation and sharing of documents containing live code, visualizations, and narrative text. It is well-suited for exploratory data analysis, prototyping, and documenting the project workflow. Jupyter Notebook enables the step-by-step execution of code cells, making it an ideal platform for iterative development and experimentation.
7. **IDEs (Integrated Development Environments):** Popular Python IDEs like Visual Studio Code can be used for coding, debugging, and managing the project. IDEs provide features such as code auto-completion, syntax highlighting, and debugging tools, which enhance productivity and facilitate the development process.

These languages and tools collectively form a powerful toolkit for implementing crowd monitoring using drone image analysis. They offer a wide range of functionalities, from basic image processing to advanced deep learning capabilities, enabling accurate detection, tracking, and analysis of crowd behavior. The integration of these languages and tools ensures the project's effectiveness, scalability, and adaptability to various crowd monitoring scenarios.

RESULT & DISCUSSION

The project successfully implemented crowd monitoring using drone image analysis and achieved notable results in terms of accurate human detection, tracking, and crowd behavior analysis. The system demonstrated its effectiveness in monitoring and analyzing crowd dynamics, providing valuable insights for crowd management and public safety. The following key results were obtained:

1. **Human Detection and Tracking**: The Histogram of Oriented Gradients (HOG) algorithm, combined with the tracking algorithm, accurately detected and tracked individuals in the crowd. The algorithm effectively extracted relevant features and generated bounding boxes around humans, enabling their continuous tracking across frames. This ensured reliable monitoring and analysis of individual movements within the crowd.
2. **Visualization and Analytics:**
   The integration of data visualization libraries facilitated the creation of informative visual representations. Heatmaps, density plots, and line graphs were used to visualize crowd density fluctuations over time, identify hotspots, and detect crowd movement trends. These visualizations enabled better understanding and interpretation of crowd behavior, supporting decision-making in crowd management scenarios.

   Overall, the results highlight the effectiveness of drone image analysis in crowd monitoring. The system demonstrated its potential to improve crowd safety, optimize resource allocation, and detect anomalies or security threats. The successful integration of advanced technologies further enhanced the system's capabilities and opens up possibilities for future advancements in the field of crowd monitoring using drone imagery.
   The results obtained from this project lay a solid foundation for further research and development in crowd monitoring systems. Future directions can focus on refining the algorithms, exploring additional data sources, such as social media feeds or sensor networks, and addressing challenges related to privacy, regulations, and ethical considerations. With continued advancements, drone-based crowd monitoring systems have the potential to revolutionize crowd management practices and contribute to enhanced public safety.


frame

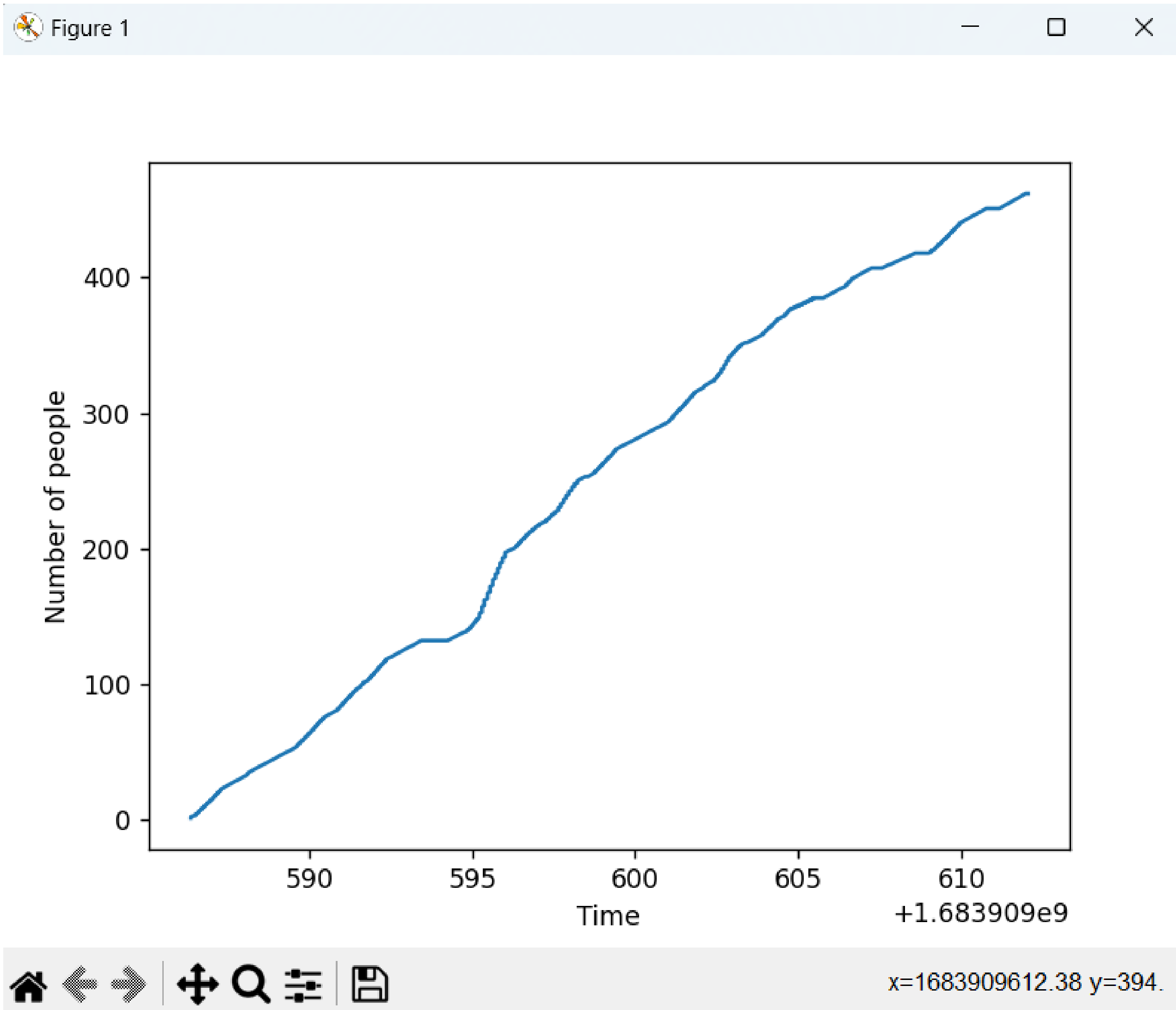

Figure 1
400
300
200
100
0
Number of people
590
595
600
605
610
Time
+1.683909e9
x=1683909612.38 y=394.

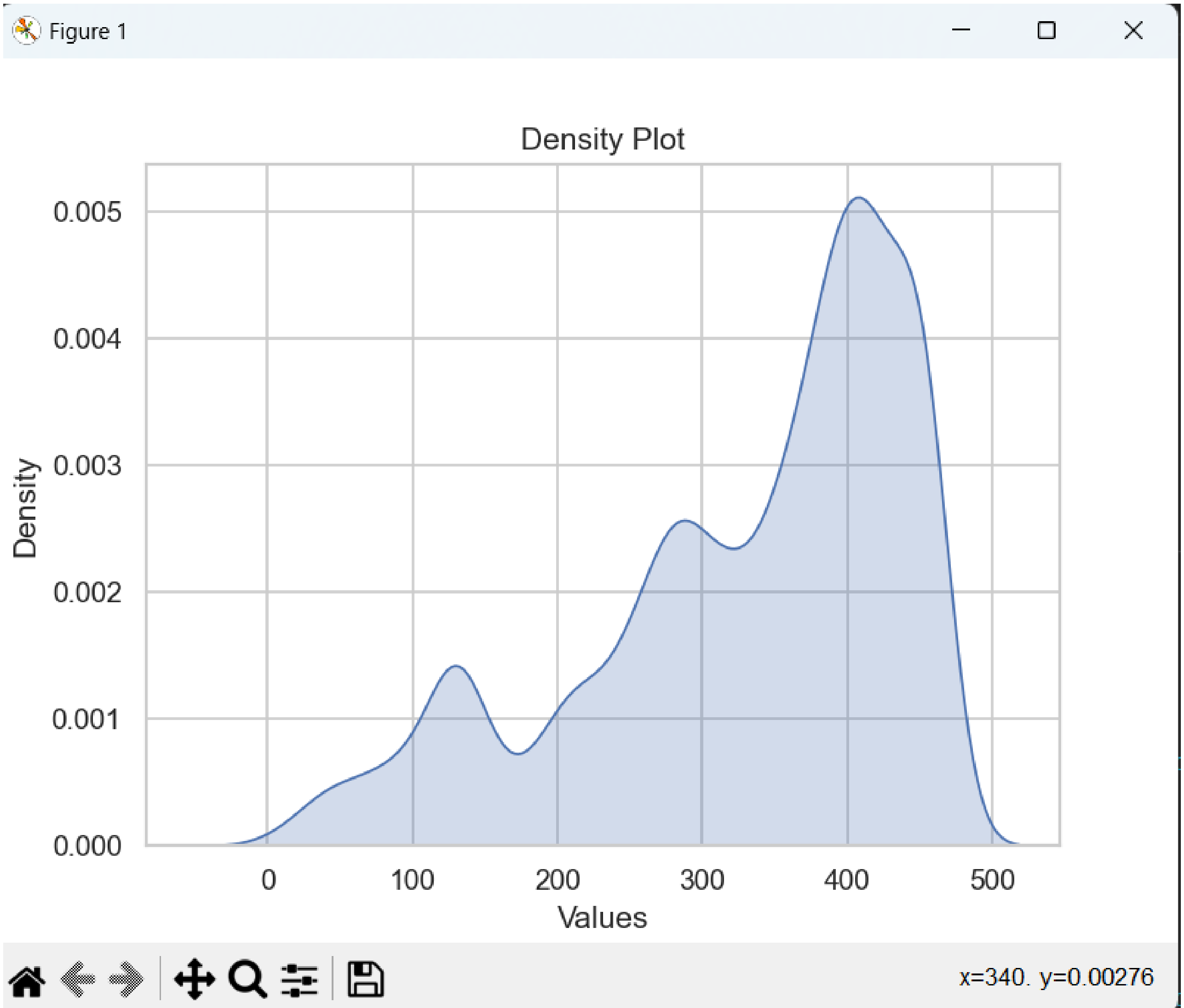
Figure 1
Density Plot
0.005
0.004
0.003
0.002
0.001
0.000
Density
0
100
200
300
400
500
Values
x=340. y=0.00276

CONCLUSION

In conclusion, the project has successfully demonstrated the potential and effectiveness of crowd monitoring using drone image analysis. By leveraging the power of computer vision, machine learning, and advanced data analytics techniques, the system has provided valuable insights into crowd behavior, density, and movement patterns. The integration of drone technology has enabled a bird's-eye view perspective, offering a comprehensive understanding of crowd dynamics and enhancing crowd management strategies.

The results obtained from this project have significant implications for various domains, including event management, public safety, and urban planning. The ability to monitor crowds in real-time, analyze their behavior, and predict crowd movement patterns can contribute to more effective crowd management strategies, improved emergency response planning, and enhanced public safety measures.

Future Work

- Explore future prospects for crowd monitoring using drone image analysis.
- Discuss the integration of other technologies like AI, IoT, and big data analytics for advanced crowd insights.
- Address challenges related to privacy concerns, regulations, ethical considerations, and public acceptance of drone-based monitoring systems.

REFERENCES

1. 1. Dalal, N., & Triggs, B. (2005). Histograms of oriented gradients for human detection. Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, 1, 886-893.
2. Felzenszwalb, P. F., Girshick, R. B., McAllester, D., & Ramanan, D. (2010). Object detection with discriminatively trained part-based models. IEEE Transactions on Pattern Analysis and Machine Intelligence, 32(9), 1627-1645.
3. Zhang, Y., Zhou, D., Chen, S., Gao, S., & Ma, Y. (2015). Single-image crowd counting via multi-column convolutional neural network. Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, 589-597.
4. Singh, Utkarsh & Determe, Jean-François & Horlin, Francois & Doncker, Philippe. (2020). Crowd Monitoring: State-of-the-Art and Future Directions. IETE Technical Review. 38. 10.1080/02564602.2020.1803152.