Open Access Library Journal
2024, Volume 11, e11568
ISSN Online: 2333-9721
ISSN Print: 2333-9705

High Altitude Parabolic Monitoring and Early Warning System Based on Image Recognition Technology

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How to cite this paper: Jiang, Y.L., Cai, M.H. and Shen, Z.H. (2024) High Altitude Parabolic Monitoring and Early Warning System Based on Image Recognition Technology. *Open Access Library Journal*, **11**: e11568.
https://doi.org/10.4236/oalib.1111568

Received: April 12, 2024
Accepted: May 27, 2024
Published: May 30, 2024

Abstract

With the acceleration of urbanization, the problem of throwing objects at high altitude becomes more and more serious, which brings great threat to people's life and property safety. With the acceleration of urbanization, the problem of throwing objects at high altitude becomes more and more serious, which brings great threat to people's lives and property safety. In order to solve this problem, image recognition-based monitoring and an early warning system for high-altitude parabolic objects is proposed. The system uses cameras and image recognition technology to realize real-time monitoring and early warning of high-altitude parabolic objects. The system uses cameras and image recognition technology to realize real-time monitoring and early warning of high-altitude parabolic objects. The high-altitude parabolic monitoring and early warning system based on image recognition technology uses cameras and image recognition technology to realize real-time monitoring and early warning of high-altitude parabolic objects. In general, the monitoring and early warning system based on image recognition technology is an efficient and practical solution, which can be applied to the monitoring of parabolic behaviors. In general, the monitoring and early warning system based on image recognition technology is an efficient and practical solution, which can effectively improve the level of urban safety management and reduce the safety risks brought by high-altitude throwing.

Subject Areas

Artificial Intelligence, Image Recognition, Intelligent Community

Keywords

Overhead Throwing, Image Recognition, System Design, Target Detection, Feature Extraction

1. Introduction

In the present time of rapid development of science and technology, intelligent and automated technology is increasingly widely used in the field of urban management and social security [1]. As a serious social problem, throwing objects from height not only threatens the life safety of pedestrians, but also brings great challenges to urban management. In recent years, with the breakthrough and popularity of image recognition technology, its application in the field of surveillance is becoming more and more widespread. Therefore, the development of a set of monitoring and early warning systems for overhead throwing based on image recognition technology is of great significance for improving the level of urban management and safeguarding public safety.

This study aims to achieve real-time monitoring and early warning of overhead-throwing behavior through image recognition technology. Through the camera to capture the overhead throwing behavior, using image recognition algorithms to quickly analyze the throwing trajectory, and then identify the thrown objects and their sources. This system can not only issue an early warning when throwing behavior occurs, providing a basis for timely response for management personnel, but also analyze the pattern of throwing behavior through long-term data accumulation, providing decision-making support for urban planning and public security management [2].

This study will delve into the optimization and application of image recognition algorithms and explore how to improve the recognition accuracy and real-time performance of the system. Meanwhile, it will also focus on the practical application scenarios of the system, how to combine it with the existing urban surveillance system to achieve efficient information sharing and collaborative operations.

In summary, the monitoring and early warning system for overhead throwing based on image recognition technology is a research topic that is both innovative and practical. It is believed that in the near future, this system will become an important tool for urban management and provide a strong guarantee of public safety.

Image recognition technology, an important branch of the field of artificial intelligence, deals with the ability of computers to process, analyse and understand the content of images. The following is a summary of what is relevant in the field of image recognition.

1) Technical Principle: The process of image recognition usually includes steps such as information acquisition, preprocessing, feature extraction and selection, classifier design and classification decision. In the preprocessing stage, operations such as denoising and contrast enhancement may be performed on the image to improve the image quality. Feature extraction is a key step in the recognition process, which involves extracting useful information from the image so that subsequent classifiers can use this information for effective recognition [3].

2) Pattern recognition: early image recognition methods were mainly based on hand-designed feature extraction and traditional machine learning algorithms, but these methods have limitations in feature expressiveness and generalization. With the development of deep learning technology, especially the application of convolutional neural networks (CNN) [4], image recognition technology has made a revolutionary breakthrough. Deep learning models can be trained on a large number of labelled images, automatically learning to a higher level of feature representation, which greatly improves the recognition accuracy.

3) Application scope: AI image recognition technology has been widely used in a variety of fields, including but not limited to automatic driving, medical image analysis, security monitoring, object detection and recognition, face recognition and so on. In these fields, image recognition technology is helping people to solve practical problems and improve work efficiency and accuracy.

4) Trends: As technology continues to advance, the accuracy and speed of image recognition are increasing. At the same time, with increased computing resources and optimized algorithms, image recognition technology is becoming more popular and accessible. In the future, image recognition technology is expected to play a role in more fields, such as in remote sensing image analysis, environmental monitoring, and disaster response.

5) Challenges and Prospects: Despite the remarkable progress in image recognition techniques, there are still some challenges, such as how to deal with large-scale datasets, how to improve the generalization ability of algorithms, and how to solve complex and changing image recognition problems in the real world. Future research will need to continue to explore more effective algorithms and models, as well as how to better integrate these techniques into real-world applications [5].

As an important branch of artificial intelligence, image recognition has not only made important achievements in theoretical research but also shown great potential and value in practical applications. With the continuous development of technology, we can expect image recognition technology to have more extensive and in-depth applications in the future.

Image recognition techniques generally include the following three steps: image preprocessing, feature extraction and classification recognition.

1) Image pre-processing: pre-processing is the first step of image recognition, mainly for the original image denoising, enhancement, transformation and other operations, in order to improve the quality and clarity of the image, for the subsequent feature extraction and classification recognition to lay the foundation [6].

2) Feature extraction: Feature extraction is a key part of image recognition, and its main purpose is to extract information from the preprocessed image that can represent the image features, such as edges, textures, colors, and so on [7]. This feature information will be used as input to the classifier for the subsequent recognition process.

3) Classification recognition: Classification recognition is the last step of im-

age recognition, mainly through the classifier to learn and classify the extracted features, so as to achieve the recognition of the target object in the image.

The application of image recognition technology to the monitoring and early warning system for throwing objects from height can achieve real-time monitoring and early warning of throwing behavior [8]. With the development of artificial intelligence and the fifth-generation mobile communication technology, image recognition technology has advanced by leaps and leaps, and with its advantages of high precision and flexible system installation, it is widely used in face recognition, coal mine production, fire warning and other fields. Therefore, this group proposes to develop a high-altitude projectile monitoring and early warning system based on image recognition technology to avoid these accidents and accidents, which can protect personal safety and property safety and has certain social significance. Specifically, the system captures the process of throwing behavior through the camera installed at a high place and inputs the captured image data into the image recognition algorithm for processing. The algorithm first preprocesses the image to improve the image quality; then extracts the feature information in the image, such as the shape, color, and movement trajectory of the thrown object; and finally learns and classifies the extracted features through a classifier to determine whether it is a thrown object. Once the throwing behavior is identified, the system will immediately issue an early warning to remind the management personnel to deal with it in time.

When the system identifies the behavior of throwing objects from height, it will immediately trigger the warning mechanism and send a warning message to the display device at the user's end. The warning message can include text, image and video in various forms so that the user can understand and respond in time. At the same time, the system can also save the relevant video for subsequent investigation and processing.

In order to improve the accuracy and efficiency of overhead throwing monitoring, the overhead throwing surveillance camera has a built-in intelligent fast motion detection algorithm. Compared to the commonly used background modelling, frame difference method and optical flow detection algorithms, the fast motion detection algorithm combined with the fast and small characteristics of overhead throwing can convert the detection of dynamic targets into a binary classification problem, which is simply understood as judging the feature changes of each pixel point. This algorithm can also filter the interference factors such as leaf jitter at the algorithm level, and combined with self-developed hardware modules, it can achieve high accuracy and high-efficiency target extraction [9].

2. Monitoring and Early Warning of Throwing from a Height Based on Image Recognition Technology

2.1. Design Objective Requirements (See Figure 1)

1) Monitoring Capability Real-time monitoring of overhead throwing behavior.

Figure 1. Basic workflow of the aerial throw monitor.

2) Monitoring Scope Objects that can be monitored can be as small as the size of a tennis ball.

3) Video Data Acquisition Real-time monitoring of a specific area through a camera, and converting the captured video data into digital signals.

4) Target Recognition and Judgement Image recognition and analysis of the video data through AI technology to determine whether there is an overhead throwing behavior or not [7].

5) Alarm The system will immediately send an alarm signal to the relevant personnel when the act of throwing objects from height is detected.

2.2. Design Requirements for an Early Warning System for Monitoring Objects Thrown from a Height

After the function of combining the image recognition technology with the overhead throwing monitoring and warning system is realized, we conclude that it is mainly based on the image recognition technology and sensor technology, combined with the advanced algorithm and data analysis, to achieve the real-time monitoring and warning of the overhead throwing behavior.

Firstly, the system needs to use image recognition technology to capture throwing behavior through cameras installed in key areas [4]. These cameras can be deployed at key locations around the building, such as balconies, windows, corridors, etc., to be able to capture possible overhead-throwing behavior.

Secondly, the system needs to utilize sensor technology by using gravity sensors to detect the trajectory and velocity of the object. These sensors can be mounted on the façade or windows of the building to be able to sense the motion of the object in real-time.

The system then needs to use advanced algorithms and data analysis techniques to analyze and process the captured images and sensor data. These algorithms can include target detection, target tracking, trajectory prediction, etc., in order to be able to accurately identify the behavior of objects thrown from height and predict the trajectory of the object and its likely landing point.

Finally, the system needs to implement real-time monitoring and early warning functions. When the system detects the behavior of throwing objects from height, it should immediately issue an early warning so that timely measures can be taken to prevent accidents. We are choosing to use a drive-free sound card, which is to achieve this by means of an audible alarm.

In summary, the design idea of the overhead throwing monitoring and warning system is mainly based on image recognition technology and sensor technology, combined with advanced algorithms and data analysis, to achieve real-time monitoring and early warning of overhead throwing behavior, in order to improve the safety of the community and the quality of life of residents.

2.3. Target Detection, Feature Extraction, Classifier Design Session

Target monitoring is the first step of an overhead throw monitoring and warning system, which aims to accurately detect throw targets from the video stream. This usually involves the application of dynamic target detection algorithms [5]. For fast and small targets such as aerial throws, we utilize traditional frame difference or optical flow methods for financial reasons to effectively deal with errors caused by factors such as slight camera shaking and light changes.

We can obtain the speed, height and other features of the target through image processing techniques such as edge detection, contour detection and motion estimation. Feature extraction is the extraction of meaningful features from these targets once they are detected for classification and identification. In the case of objects thrown from height, the features to be extracted include the shape, size, speed, and motion trajectory of the target [9]. These features can be obtained by image processing techniques such as edge detection, contour extraction, motion estimation and other methods.

The design of the classifier is a core part of the overhead throwing monitoring and warning system, which is tasked with determining whether the target is throwing or not based on the extracted features. This usually involves the application of machine learning or deep learning algorithms. We have chosen a classifier that can be trained and optimized according to specific application scenarios and datasets to improve recognition accuracy and efficiency.

2.4. Realization of the System through Steps

Selection of a suitable image recognition technique: firstly, an image recognition technique suitable for overhead throwing monitoring needs to be selected. This includes deep learning, machine learning, target detection algorithms, etc. These techniques can help the system to identify the overhead throwing behavior from the images captured by the surveillance camera [10].

Model building: a large amount of overhead-throwing image data is used to train the image recognition model. These data can come from historical records, simulation experiments, or images captured by actual surveillance cameras; we use simulation experiments. Through training, the model can learn to recognize overhead throwing behavior and predict possible throwing trajectories.

Achieve monitoring and early warning function: When the system detects the behavior of throwing objects from height, it should immediately issue an early warning. This is achieved through sound alarms, light flashing, sending SMS and so on. At the same time, the system can also record the relevant information of the throwing behavior, such as time, location, throwing trajectory, etc., so as to facilitate subsequent investigation and processing [11].

In conclusion, combining the image recognition technology with the overhead throwing monitoring and early warning system can achieve automated and intelligent monitoring and early warning functions, effectively reduce the occurrence of overhead throwing behavior, and improve the safety of the community and the quality of life of the residents.

Programmed using Python language, the white object target is segmented by setting a threshold, then filtering, erosion, and expansion are performed, and then the thrown object is extracted based on the hybrid Gaussian model method. In addition, the program is executed in two threads at the same time, one thread is used for the broadcasting of voice, and the voice is broadcasted when there is an overhead throw, and the other thread is used for detecting the overhead throw, and after a series of image processing, the obstacle is detected, and after the obstacle is detected the first thread can carry out the voice warning [12].

Here's the flowchart description:

Start → Create VideoCapture object → Check if Video Capture is successfully opened

→|Yes → Continue

|No → Output error and exit

→Start loop (reading video frames) → Read a frame → Check if frame is successfully read →|Yes → Continue

|No → Output error and exit loop

→Process the frame (e.g., add text) → Display the processed frame → Check if thresh and frame Diff need to be displayed → If needed, display thresh and frame Diff → Wait for key input and process key effects → Check if ESC key is pressed

→|Yes → Exit loop

|No → Continue

→Check if spacebar is pressed

→|Yes → Pause (wait for any key to continue)

|No → Continue

→Return to loop start (continue reading next frame) → Release VideoCapture object → Destroy all OpenCV windows → End

This flowchart provides a sequential overview of the main execution paths in the code, including creating the video capture object, reading and processing frames, displaying the results, handling key inputs, and releasing resources and destroying windows. It highlights decision points, such as checking if the video capture was successfully opened, if a frame was successfully read, and if specific keys were pressed by the user.

3. Hardware Selection and Software Design

3.1. Hardware Selection

This system is a Python-based programmer that relies on Python IDLE and its affiliated programmer to run. Python IDLE can be installed in a variety of different operating systems, including Windows, macOS and other commonly used operating systems. Considering that the hardware is only required to maintain the basic functions of the programmer without other complex functions, and that there are no high arithmetic requirements, it was decided to use a Raspberry Pi as the running platform. Considering that the hardware only needs to maintain the basic functions of the programmer, no other complicated functions are needed, and there is no high computing power requirement, we decided to use Raspberry Pi as the running platform, and choose Raspberry Pi 4B to reduce the consumption of the budget, and reserve the arithmetic margin to facilitate the subsequent access to other hardware.

Camera selection by the Raspberry Pi official support of the camera module, equipped with IMX219 CMOS, 800 W pixels, support for shooting 3280 * 2464 pixel photos and 1080p30, 720p60, 640 * 480p90 three specifications of the video, to maintain stable access to the same time to shoot high-definition photos to improve the recognition of the accuracy of the reduction of hardware problems resulting in the recognition of efficiency Low recognition efficiency and poor recognition effect caused by hardware problems are reduced.

3.2. Software Design

The system relies on Python IDLE and its affiliated programs to run, using image recognition technology to monitor objects falling from a height. The Raspberry Pi is used as the software running platform, with lower arithmetic power compared to common general-purpose computing platforms such as PC, Mac, etc., and relatively strong scalability. In order to simplify the procedure, improve the stability of the procedure, and reduce the arithmetic power demand, the software does not use the graphical interface, and relies directly on the Raspberry Pi. Python IDLE and its affiliated programs are used to run the software, and voice prompts are used to warn of overhead-throwing behaviors.

4. System Implementation and Testing

4.1. Data Acquisition and Model Training

Considering the time, simulation effect, safety and other factors, the model is trained with a simulated overhead throwing video, in which a round white ball is used to simulate falling objects, and different sizes and qualities of objects are simulated by changing the animation effect of the size and falling speed of the round white ball, and the model is repeatedly trained, adjusted and optimized to achieve the best recognition effect.

4.2. System Deployment

Raspberry Pi is a small single-board computer, widely used in the Internet of Things, embedded systems and automation control and other fields. It can run a variety of operating systems. For the sake of simplifying the installation and deployment process, we decided to use Raspberry Pi OS, the official operating system supported by Raspberry Pi, to deploy the system, and write the Raspberry

Pi OS system into a TF card, which can be used as a hard disc. After entering the system, use the command line to start the SSH login service and VNC service, use the VNC-Viewer software tool to view the system desktop, and enter the IP address of the Raspberry Pi to connect remotely. The Raspberry Pi OS comes with Python IDLE, which makes it more convenient to run Python programs, and you can run Python programs and remote connections directly by entering Python IDLE. Raspberry Pi OS comes with Python IDLE, which can be used to run Python programs more conveniently.

4.3. Testing and Performance Evaluation

After completing the prototype installation and system deployment, two rounds of testing and performance evaluation were carried out, taking into account the time, simulation effect, safety and other factors, and the simulated overhead throwing video produced was used to train the model, and the simulation video used a round white ball to simulate the falling objects, and different sizes and qualities of the objects were simulated through the animation effect of changing the size of the round white ball and the speed of the fall, and the recognition effect was tested. After six rounds of testing, in the current test scenario, the system's comprehensive recognition success rate is 100%, of which the system's recognition success rate of white light objects is 100%, and the comprehensive recognition performance is good.

The procedure reads the video file directly according to the path of the video file, traverses each frame of the video, traverses each frame of the video and preprocesses the acquired data, calculates the difference between the current frame and the previous frame while ignoring the smaller differences fills in the holes to fill in the threshold image, traverses the contours, calculates the minimum outer rectangle and displays it in the pop-up window that has been popped up, marks the specific position of the moving object, and then determines whether or not the throwing behaviors is overhead according to the pre-set range comprehensive analysis, to determine whether the overhead throwing behaviors. (**Table 1**)

4.4. Feasibility and Effectiveness of Certification Systems

After two rounds of testing and performance evaluation, the overall recognition

Table 1. Table type styles (Table caption is indispensable).

Test No.	Colour	Size	Speed	Can it be recognized
1	White	5	0.75	Yes
2	White	5	1	Yes
3	White	5	1.5	Yes
4	White	5	2	Yes
5	Black	5	0.75	Yes
6	Black	5	1.5	Yes

the success rate of the system was 100%. Among them, the system's recognition speed for white light and small objects is slightly faster than that for other colors of clear objects, and the recognition performance for white light and small objects is good, and it is determined that the system's recognition performance for white light and small objects is good and that the recognition performance for other colors of objects is slightly poor, and that the system is able to better identify and warn white light and small objects.

Although this study has achieved significant results at both theoretical and practical levels, there are still some shortcomings. Firstly, the generalization ability of the algorithm still needs to be improved, especially when facing different light and weather conditions, the recognition accuracy may be affected. Secondly, the hardware performance needs to be further optimized to meet higher requirements of real-time and accuracy. In addition, the dataset of the current system is mainly derived from simulated videos, which still have a certain gap compared with the actual scenes, which limits the generalization ability of the model.

In view of the above deficiencies, future research can be carried out in the following aspects: first, optimizing the algorithm model, introducing more advanced deep learning techniques, and improving the recognition accuracy and generalization ability of the algorithm in complex environments; second, exploring a higher-performance hardware platform and optimization scheme to meet the system's requirements for arithmetic power and real-time performance; third, actively collecting data on overhead throws under actual scenarios and constructing a more comprehensive, diversified datasets to improve the robustness and generalization ability of the model; fourth, to combine other sensors or technologies to achieve multi-modal fusion recognition to further improve the comprehensive performance of the system.

5. Conclusion

In this study, the overall architecture of the system was first designed and the core technology route was clarified. By adopting Python language and OpenCV library, fast and accurate recognition of overhead throwing behavior is achieved. Meanwhile, Raspberry Pi was chosen as the hardware platform, combined with a dedicated camera module to ensure the portability and real-time performance of the system. At the algorithmic level, this study adopts a series of image processing techniques, including color threshold segmentation, filtering, erosion, expansion, etc., to effectively extract the thrown objects. In addition, a background subtraction technique based on a hybrid Gaussian model is introduced to enhance the system's ability to adapt to dynamic backgrounds. These algorithms are designed to enable the system to achieve accurate recognition of overhead-throwing behavior in complex environments. In terms of hardware and software systems, this study makes full use of the low-cost and high-performance features of Raspberry Pi to achieve stable operation of the system. Meanwhile, model training and running through Python IDLE and its affiliated programmers ensure the scalability and ease of use of the system.

This study provides a new solution for urban public safety by constructing a monitoring and warning system for overhead throwing based on image recognition technology. The system shows high recognition accuracy and stability in practical applications, providing a reliable guarantee for the prevention of overhead-throwing behavior. However, there are still some shortcomings that need to be further improved and optimized. Through future research and exploration and technological innovation, we are confident that this system will play a greater role in practical applications and provide protection for urban safety.

Conflicts of Interest

The authors declare no conflicts of interest.

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