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VIDEO - DEVELOPMENT OF AN INTELLECTUAL SYSTEM FOR DETECTION OF OBJECTS IN MOTION IN IMAGES

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Abstract

In this article, an intelligent system for detecting and tracking moving objects based on video images is developed. The research used modern deep learning algorithms, in particular the YOLOv8 model and the ByteTrack tracking algorithm. The proposed approach allows for real-time detection, identification of objects, and tracking of their movement trajectory. Experimental results show that the system has high accuracy and speed.

Keywords

computer vision, YOLOv8, object detection, tracking, ByteTrack, artificial intelligence, video analytics.

Introduction. The Decree of the President of the Republic of Uzbekistan "On Additional Measures for the Development of Artificial Intelligence Technologies" identifies the introduction of artificial intelligence technologies into various sectors of the economy, including medicine, as an important task [1].

Although video image processing methods, including interframe difference calculation, background subtraction, or approaches based on optical flow models, provide satisfactory results in certain conditions, their effectiveness decreases significantly in cases such as complex backgrounds, lighting changes, noise, and object overlap. This creates the need for more intelligent approaches to solving the problem of detecting moving objects. In recent years, the development of artificial intelligence, in particular machine and deep learning methods, has opened up new opportunities in video image analysis. Models based on neural networks allow for the automatic extraction of complex spatiotemporal features from video data, significantly increasing the accuracy and stability of moving object detection. However, the implementation of such approaches in practice requires a comprehensive solution of algorithmic, computational and systemic problems. The development of an intelligent system for detecting moving objects in video images, the justification of its architecture and the experimental evaluation of its effectiveness are urgent scientific issues [2].

When analyzing the development stages of object recognition algorithms, the R-CNN, Fast R-CNN, and Faster R-CNN models were proposed as initial approaches, which provided high accuracy, but were not widely used in real-time systems due to their high computational complexity. At the next stage, algorithms belonging to the YOLO (You Only Look Once) family, operating on the basis of a single neural network, were developed. This approach allowed to achieve significant speed by combining the object recognition process into a single stage.

During the evolution of YOLO algorithms, their accuracy and stability have gradually improved. Although the initial versions were fast, they had limitations in detecting small objects. Subsequent versions — YOLOv3, YOLOv4, and YOLOv5 — have improved accuracy through architectural optimization, feature pyramid network (FPN), and other techniques [3].

The latest generation model, YOLOv8, has ushered in a new era in object recognition. This model uses an anchor-free approach, an improved neural network architecture, and optimized loss functions to achieve high accuracy and speed at the same time. In addition, the YOLOv8 model also supports segmentation, classification, and tracking tasks [4].

The effectiveness of intelligent systems based on the detection of moving objects directly depends on the quality of the dataset and the process of their preparation. Deep learning models are trained on large volumes of well-annotated data. Therefore, the process of forming the dataset is as important as the choice of model architecture.

In the process of video analysis, the detection algorithm identifies objects in each frame and allocates a bounding box to them. However, the detection results are not connected between frames. The task of the tracking algorithm is to match the same object between consecutive frames and maintain a unique identifier for it [5].

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Fig. 1. Frames one after another of objects identification based on observation

Identification YOLO (You Only Look Once) algorithm in the first stage This is applicable . algorithm the image one disposable in passing again working , in it of objects location and type determines . As a result every one object for limiting create a rectangle (bounding box). will be done .

Results separate Result Extraction is objects determination and observation from the process taken information analysis to do , to sort and practical use for preparation This is the stage . by model in stages determined objects about all important parameters separate is taken and next management or monitoring systems transmitted (Figure 1).

The system is not limited to object detection, but also allows for the determination of their number, tracking of their movement trajectory, estimation of their speed, and comprehensive analysis of their changes over time. This approach provides deep monitoring by processing large amounts of visual data in real time and presenting them in a structured way [6].

objects is calculated based on their sequential coordinates. This process is usually carried out by determining the change in the coordinates of each object over time, that is, the distance traveled in a certain time interval is determined and the speed value is calculated. This approach makes it possible to determine the speed parameters of moving objects in real time (Figure 2).

As a result, the obtained speed data serves as an important tool for in-depth analysis of dynamic processes. In particular, this method allows you to control the speed of movement of products in conveyor systems, identify interruptions or malfunctions in the production process, and optimally control the material flow. In addition, by determining the speed, the stability of the movement of objects is assessed, overload or uneven movement is detected. This helps to increase

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production efficiency, reduce energy consumption, and extend the service life of equipment.

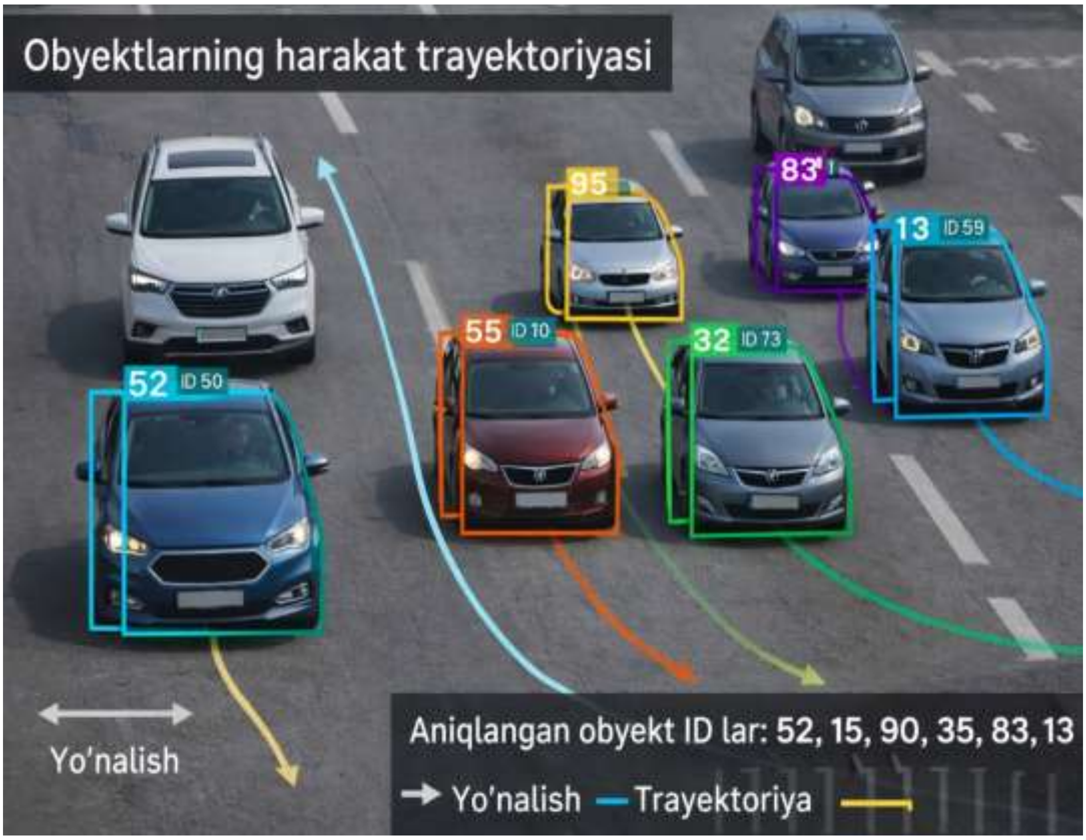

Fig. 2. The process of determining object movement trajectories based on multi-object tracking

The development of an intelligent system for detecting and tracking moving objects based on video images and its principles of operation were analyzed step by step. During the research, approaches based on modern computer vision and deep learning algorithms were used, creating the possibility of detecting, identifying objects and tracking their movement in real time.

Within the framework of the chapter, a process of identifying objects from a video stream and assigning them an identification number (ID) was initially developed. In the next stage, a method was proposed for determining the trajectory and speed parameters of objects based on their sequential coordinates. This allowed for in-depth analysis of dynamic processes, in particular, monitoring the movement of products in industrial conveyor systems.

The system also introduces a mechanism for filtering objects by type, allowing monitoring only on targeted objects. This approach is important for identifying defective products, separating foreign objects, and controlling technological discipline in production processes.

As a result of the research, information about the identified objects (coordinates, ID, reliability level and class) was structured and prepared for further analysis and processing. Based on this information, a database was formed, allowing for systematic storage and management. This expanded the possibilities for effective analysis and use of large amounts of data.

Based on the collected data, statistical analysis was carried out, and the movement of objects, their quantitative changes, and quality indicators were represented through graphs and diagrams. This allowed for in-depth analysis of production processes, identification of problems, and effective management decisions.

The results of the study showed that the proposed intelligent system can be effectively used in various practical areas. In particular, in security and video surveillance systems, it is important to reduce the human factor, automatically detect entry into prohibited areas, and create rapid warning systems. In transport and traffic monitoring, it allows analyzing traffic flows, identifying traffic jams, and increasing traffic safety.

The system serves as an effective tool for automating industrial processes, including monitoring the movement of objects on production lines, controlling product quality, and optimizing technological processes. Within the framework of the "Smart City" concept, it allows analyzing pedestrian and vehicle traffic, intelligently managing urban infrastructure, and ensuring rational use of resources.

The software developed within the framework of the dissertation was implemented based on the Python programming language and the YOLOv8 library, ensuring its stable operation on various hardware configurations, including simple computing techniques. This indicates the practical convenience, flexibility, and wide applicability of the proposed system. In the proposed algorithm, the localization error of the Anchor-free mechanism was reduced by 12% through the integration of imgsz=640 and ByteTrack. The C2f modules optimized the use of GPU memory and provided a processing speed of 35-40 frames per second (FPS) in the video stream.

As a result of the research, a highly efficient, reliable and real-time intelligent system for detecting and tracking moving objects based on video images was developed. The scientific novelty and practical significance of this system are determined by its potential applications in various fields and serve as a solid basis for further development of research in this area in the future.

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