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IMPROVEMENT OF OBJECT DETECTION AND CLASSIFICATION ALGORITHMS IN COMPUTER VISION SYSTEMS

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Annotation

This article analyzes the issues of improving object detection and classification algorithms in computer vision systems. As a result of the rapid development of modern artificial intelligence technologies, especially deep learning methods, the possibilities of accurately separating objects from image and video streams are expanding. The article considers the principles of operation of existing convolutional neural networks (CNN), region-based detection models, as well as their advantages and limitations. New approaches aimed at increasing accuracy, improving computing speed, and reducing resource consumption are also described. Data set expansion, image preprocessing, transfer learning, and the use of ensemble models are shown as important factors for improving efficiency. The practical significance of such improved algorithms in areas such as real-time surveillance systems, medical image analysis, industrial control, and autonomous transportation is highlighted. The research results show that the reliability of detection and classification processes is significantly increased by using optimized model architectures and adaptive training strategies.

Keywords

computer vision, object detection, classification algorithms, deep learning, convolutional neural networks, artificial intelligence, image processing, real-time systems, transfer learning, model.

As a result of the rapid development of information technologies, the volume of image and video data is increasing dramatically. The need to analyze this data without human intervention has led to the rapid development of the field of computer vision. One of the most important tasks of computer vision systems is the detection of objects in an image (object detection) and their correct classification (classification). These processes are widely used in many practical areas of artificial intelligence - security systems, medical diagnostics, industrial automation, agriculture, transport and robotics.

At the same time, complex conditions in the real environment - changes in illumination, complexity of the background, partial occlusion of objects, their location at different scales and angles - place high demands on existing algorithms. Therefore, improving object detection and classification algorithms is an urgent scientific and practical issue.

Computer vision systems typically consist of several stages:

Image acquisition – acquiring information from a camera or sensor

Pre-processing – reducing noise, increasing contrast

Feature extraction

Object detection – finding the location of an object in an image

Classification – assigning a detected object to a specific class

While in the early years these processes were performed based on manually developed features (SIFT, SURF, HOG), deep learning approaches are now taking the lead.

Traditional algorithms extract special features based on the edges, texture, and shape of an image, and then perform classification using classifiers (SVM, k-NN, Random Forest). However, these approaches have the following drawbacks:

Low accuracy in complex background conditions

Unstable performance when the object shape changes

Slow performance on large amounts of data

Need to select features manually

Therefore, methods based on neural networks that learn features on their own have begun to gain dominance.

Convolutional neural networks (CNNs) are one of the most efficient architectures for image processing. CNNs automatically learn important spatial features in an image. Lower layers detect simple shapes, while upper layers detect complex object structures.[2]

CNN-based models are achieving high accuracy rates by combining object detection and classification. Especially when large data sets are available, such models provide results close to human accuracy.[3]

Development of object detection algorithms

The problem of object detection has developed in two main directions:

Two-stage detectors. In these methods, first the probable object regions are identified, and then they are classified.

Popular models:

R-CNN

Fast R-CNN

Faster R-CNN

Their advantage is high accuracy, but the disadvantage is low computational speed.

One-stage detectors. These models perform object detection and classification at the same time.

Popular models:

YOLO (You Only Look Once)

SSD (Single Shot Detector)[1]

RetinaNet. This approach is used in real-time systems It is very convenient for deep learning because of its high speed.

Deep networks have many parameters and require large computational resources. Therefore, lightweight architectures (MobileNet, EfficientNet) have been developed. Such models work effectively on mobile devices and embedded systems.

Adjusting the number of layers, using skip connection and attention mechanisms helps to increase accuracy.

Data Augmentation. The generalization ability of the model largely depends on the training data. The number of data is artificially increased by rotating images, changing their scale, modifying lighting, adding noise. This makes the model adaptable to real conditions.[4]

Adapting pre-trained models on large datasets to a small dataset is called transfer learning. This method reduces training time and increases accuracy, and is especially useful in special areas (medical imaging, industrial defects).

The final accuracy is increased by combining the results of several models. For example, one model may be sensitive to shape, and another to color. Their combination gives a more reliable result.

Classical loss functions are not always effective in object detection. Functions such as Focal Loss focus more on learning difficult examples and reduce the problem of unbalanced classes.

Attention modules help the model to focus on important parts of the image. This is especially effective for object separation in images with complex backgrounds.

Algorithms for autonomous cars, video surveillance and drones need to run fast. For this:

Model quantization

Parameter compression (pruning)

Acceleration libraries such as TensorRT[6]

are used. These methods increase the speed of operation several times while almost maintaining accuracy.

Applications in various fields

In medicine – tumor detection from X-ray and MRI images

In transportation – pedestrian, road sign, and other vehicle detection

In agriculture – plant disease classification

In industry – manufacturing defect detection

In security – face detection and suspicious activity tracking

Since each field has its own unique data and conditions, it is important to adapt algorithms.

Current systems still face the following problems:

Decreased accuracy in low-light environments

Difficulty in detecting very small objects

Vulnerability to adversarial attacks

High energy consumption

In the future, self-supervised learning, multimodal systems, and neuromorphic computing will be of great importance.[5]

In conclusion, improving object detection and classification algorithms in computer vision systems is one of the main directions of artificial intelligence development. With the help of deep learning, optimized architectures, enriched datasets and effective training strategies, systems are becoming more accurate, faster and more reliable. Creating models that are adaptable to real-time systems, resource-efficient and stable under various conditions will remain the main goal of future research.

Thus, improving algorithms is of great importance not only theoretically, but also practically, as it serves to make many areas of human life safer, more convenient and more efficient.

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