International Journal of Digital Crime and Forensics
Volume 16 • Issue 1 • January-December 2024

Laboratory Abnormal Behavior Detection Based on Multimodal Information Fusion

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ABSTRACT

The traditional laboratory anomaly detection methods mainly focus on the hidden dangers caused by chemical leaks and other items, ignoring the impact of abnormal behaviors such as incorrect operations and improper behavior on safety in the laboratory. This paper proposes a laboratory abnormal behavior detection method based on multimodal information fusion. The method generates a dense optical flow field of RGB image sequences based on optical flow theory and global smoothing constraints, and mines motion mode information. Meanwhile, the contour modal information of behavior is captured through convolution and adjacency matrix operations. Using decision level and proximity functions to integrate student behavior motion mode information and contour mode information, and using the maximum value as the behavior detection result. The experimental results show that the method can effectively detect abnormal behavior in the laboratory environment, with small detection errors and a specificity close to 1.00, effectively ensuring the safety of the laboratory environment.

KEYWORDS

Multimodal Information Fusion, Optical Flow Theory, Abnormal Behavior Detection, Motion Mode Information, Contour Modal Information

INTRODUCTION

Behavioral management in laboratory environments is crucial for the safety of students and the normal operation of the laboratory. Although most students can abide by laboratory rules, unsafe behavior arises due to their weak safety awareness, lack of self-protection awareness, weak psychological resilience, and tendency to make unwise decisions in the event of laboratory accidents. At the same time, group factors also have an indirect impact on laboratory safety. The group environment in which students live is significant, and their goals and pressures have a direct impact on individual behavior. If the group safety atmosphere is poor, individuals are easily affected in both learning and living environments, and many students are driven by conformity psychology to unconsciously engage in unsafe behavior (Zhang et al., 2022; Li et al., 2022). Therefore, the detection of abnormal behavior in university laboratories has become an issue of high concern.

At present, research on unsafe human behavior pattern recognition, both domestically and internationally, mainly focuses on abnormal behavior detection using artificial intelligence. For example, Zhang et al. (2003) established an abnormal behavior detection network model using the fifth version of the "you only look once" (YOLO) family of object detection models network and a masked convolutional attention model. They learned and extracted behavior features through each

DOI: 10.4018/IJDCF.350265

layer of the network and classified normal and abnormal behavior features using cross entropy loss function to achieve abnormal behavior detection. Xiao et al. (2002) used a spatiotemporal encoder to mine the spatiotemporal features of each frame in behavioral video images. They used attention mechanisms to weigh these features and used sigmoid functions and cross entropy loss functions to obtain the error between predicted and actual frames. Based on this result, they judged whether the current behavior was abnormal. Li et al. (2023) used the third version of the YOLO family of object detection models and regression methods to extract behavioral features, classified them through multitask learning, and completed abnormal behavior detection. Qian et al. (2020) established an abnormal behavior monitoring system using residual networks, obtained behavioral characteristics through convolutional kernel operations, and judged whether the behavior was abnormal based on the loss function value of each residual block. Although the existing technology for detecting abnormal behavior in school laboratories has made some progress, it still faces many challenges. Abnormal behavior detection requires a large amount of accurate and complete data to train and validate the model. In practical applications, data may have issues such as noise, missing components, or errors, which can affect the accuracy and reliability of the model. Liu et al. (2024) proposed a dangerous driving behavior prediction method based on the convolutional neural network-long short-term memory network and self-attention mechanism, which was used for historical driving data of trucks in a certain province. Through feature screening, spatial feature extraction, temporal information capture, and self-attention mechanism prediction, high prediction accuracy was achieved. However, the combination of the convolutional neural network-long short-term memory network and self-attention mechanism may lead to high model complexity, resulting in good performance on training data but poor generalization ability on unknown data. Shen et al. (2024) designed a composite network based on the rotating object detection model rRetinaNet and the convolutional recurrent neural network text recognition algorithm combined with attention mechanism to solve the problem of number plate recognition in athlete identity recognition with abnormal behavior, especially optimizing the number plate tilt distortion and small changes in aspect ratio. Although rRetinaNet can handle rotating targets, recognition performance may decrease for number plates with extreme angles or irregular shapes. Ren et al. (2024) designed an intelligent vision based auxiliary monitoring system for abnormal behavior of personnel in substations. By connecting hardware modules with a CC2530 wireless chip and combining artificial intelligence and image processing technology, they achieved preprocessing, background modeling, and information description of shadows in monitoring videos. They also used the histogram of oriented gradients feature recognition technology to detect abnormal behavior, improving the accuracy of monitoring recognition. In complex monitoring scenarios, there may be various interference factors, such as personnel occlusion, motion blur, etc., which may affect the accuracy of abnormal behavior detection.

Multimodal information fusion is a technology that processes multiple sources of information, aiming to integrate these different sources to obtain more comprehensive, accurate, and reliable information. In laboratory abnormal behavior detection, multimodal information fusion technology can integrate information from different data sources, such as video, audio, sensor data, etc., to achieve high-precision and efficient capturing and descriptions of complex behaviors and events in the laboratory environment, thereby more accurately detecting abnormal student behavior. To this end, a laboratory abnormal behavior detection based on multimodal information fusion is proposed.

RESEARCH METHOD

Laboratory Behavior Modal Information Mining

Acquisition of Student Behavioral Movement Modal Information

The optical flow field can capture the movement patterns of pixels or feature points in the laboratory student behavior video sequence, thereby reflecting the students' dynamic behavior (Bohan