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Elhajj et al. employed a CNN-RNN pipeline for tool identification in surgical videos. Instead of training both networks end-to-end, they introduced a reinforcement strategy that uses weakly supervised classes to guide the training of CNNs to align with the output of RNNs [34]. Nwoye et al. proposed a deep learning framework trained using binary annotations to perform tool presence and tool tracking [31]. They used ConvLSTM (Convolutional LSTM) to learn spatiotemporal features in surgical videos. Recently, Wang et al. demonstrated the capability of using Graph Convolutional Networks (GCNs) to learn temporal relationships across consecutive frames [35]. Their method involved using video sequences of labeled frames and unlabeled close processes, and achieved significant improvements compared to reference methods. In recent years, deep learning tools have been widely used for surgical instrument detection. Among these, Bajraktari et al. [36] proposed a method based on CNN neural network for detecting surgical instruments in limited surgeries. In another study, Ran et al. [37] suggested a method based on the YOLOv7x model for detecting surgical instruments in open and complex surgeries. Zheng [38] utilized the YOLOv7 model for detecting surgical instruments in limited and small surgeries. Bai [39] employed tracking and deep learning-based detection techniques for surgical instrument detection. In the reviewed methods, it has been observed that few studies focus on image preprocessing and simplification for surgical tool detection. In this method, while utilizing the approach presented in [16], which is based on LSTM-CNN, edge detection has been used as a preprocessing step to improve the detection of surgical tools. The goal of this step is to eliminate noise and non-tool tissues and simplify the image data. Thus, edge information can enhance the phase transitions and movements in the LSTM-CNN model. The following section provides a detailed explanation of this process. The main challenges of previous articles include not considering specific features and appropriate preprocessing for image analysis. To improve processing speed and meet the constraints of real-time processing, it seems necessary to reduce the volume of irrelevant information from the image and have image processing models focus only on regions where changes occur. Therefore, presenting methods for representing these changes is essential. In this article, the use of edge detection tools is proposed to address this issue. The reason for using edge information in the image is to eliminate irrelevant information and emphasize useful information. 3.

Proposed Method This section describes the tools used and the proposed method in the article. 3.1 Dataset The Cholec80 dataset, created by A. P. Twinanda et al. [28], was used in this work. This dataset consists of endoscopic videos of 80 cholecystectomy surgeries performed by 13 surgeons at the University Hospital of Strasbourg. The videos were recorded at a frame rate of 25 frames per second (fps), and the surgical phases were continuously labeled, while the surgical tools were labeled at a rate of 1 Hz. Therefore, each frame with a tool label is surrounded by 48 unlabeled frames. Surgeons used seven tools for the laparoscopic intervention, including grasper, bipolar, hook, clipper, scissors, irrigator, and specimen bag. The length of the videos had an average of 2095 seconds (minimum: 739, maximum: 5993, first quartile: 1641, third quartile: 2882). 3.2 Edge Detection Edge detection is one of the crucial stages in image processing and machine vision that deals with detecting and distinguishing edges in images. Edges are points in the image that indicate sharp changes in color or intensity of light and define the boundaries of different objects. The main goal of edge detection in machine vision is to detect and extract edges present in the image for use in other tasks such as pattern recognition, object detection, and image processing for visual analysis. Various algorithms exist for edge detection that utilize different filters, methods for detecting changes in color intensity, and image processing techniques to identify edges. Through edge detection, machines will be able to obtain useful information from the image and perform more precise and intelligent actions. This process enhances the performance of artificial intelligence systems and machine vision in pattern recognition, object detection, and image analysis. In this article, the following algorithms are independently used for image edge detection. Sharp Algorithm: The Sharp algorithm is a simple method for edge detection that highlights differences between neighboring pixels by filtering the image with sharpening filters. This algorithm usually enhances and emphasizes edges in the image. Sobel Algorithm: The Sobel algorithm is a widely used method for edge detection that calculates the gradient of the image using Sobel filters in perpendicular directions. This algorithm effectively identifies horizontal and vertical edges in the image. Canny Algorithm: The Canny algorithm is an advanced and precise method for edge detection that involves several different stages such as Gaussian filtering, gradient calculation, non-maximum suppression, and edge detection and merging. This algorithm is well-suited for identifying thin and precise edges in images. Roberts Algorithm: The Roberts algorithm is a simple method for edge detection that calculates differences between neighboring pixels using two 2x2 filters. This algorithm is useful for identifying thin and angled edges in images. Prewitt Algorithm: The Prewitt algorithm is relatively similar to the Sobel algorithm and calculates the image gradient using Prewitt filters in horizontal and vertical directions. This algorithm is relatively fast and efficient for edge detection in images. Overall, different edge detection algorithms utilize filtering and gradient calculations to identify and emphasize edges in images, each with its own features and capabilities. In this article, edge extraction is used to remove incorrect information from the image and extract useful information from it. The goal of edge extraction is to retain useful information and eliminate unnecessary details from the image. According to Figure 2, in this research, the following edge detection algorithms were independently used. That is, only one of the edge detection algorithms was used in each program execution, and the results were examined. Two objectives are pursued by this action.

Sources