Circuit Component Detection in Offline Hand-drawn Electrical/Electronic Circuit Diagram

Archan Bhattacharya

Department of Electronics and Telecommunication Engineering, Jadavpur University, Kolkata, India

Navonil Sarkar

Department of Electronics and Telecommunication Engineering, Jadavpur University, Kolkata, India

Soham Roy

Department of Electronics and Telecommunication Engineering, Jadavpur University, Kolkata, India

Samir Malakar*

Department of Computer Science, Asutosh College, Kolkata, India

Ram Sarkar

Department of Computer Science and Engineering, Jadavpur University, Kolkata, India

*Corresponding author: malakarsamir@gmail.com

Abstract— Detection of circuit components from hand-drawn circuit image refers to the process of automatic separation of all the circuit components belonging to a circuit. In this work, we have devised an algorithm that accepts a hand-drawn circuit image as input and returns the circuit components marked with bounding box. We have proposed a method where we have used the morphological 'close' operator to create a structural dissimilarity between the circuit components and the wires. Then we have used run length smoothing algorithm (RLSA) based technique to remove all the wires. Finally, we have used the spatial coordinates of the circuit components in the wire-removed circuit diagram to localize them in the actual circuit diagram. The proposed methodology is evaluated over a database consisting of 60 circuit images collected from the copies of engineering students. Considering the complexity of the research topic, the result thus obtained is encouraging.

Keywords— *circuit component detection, electrical/electronic circuit, hand-drawn circuit, morphological operation, RLSA*

I. INTRODUCTION

Circuit in layman terms is a closed path that allows electricity to flow from one node to another. This path consists of connecting wires which connect different electrical and/or electronic components. Circuit components can broadly be classified as electrical and electronic circuit components which allow uninterrupted flow of electricity or transfer of power through a circuit.

To understand and analyse real life circuits, circuit components are drawn following certain internationally accepted figures called circuit symbols. Each circuit component has its own unique symbol. The detection of such elements is, however, a cumbersome job but inevitable for circuit analysis. For circuits taken in bulk it becomes even more hectic. Here lies the need of automatic detection of circuit components. Digital image processing, the use of computer algorithms to process digital images, acts as a viable option for this automatic analysis of the circuit images.

In this context, it is noteworthy to mention that nowadays tools (like CircuitMaker, Computer-aided design (CAD), CircuitStudio) are available to draw circuit diagrams in online mode, most of which are commercially used. But, the common users prefer to draw circuit diagrams in hand rather than using such tools. Even, drawing a circuit using such tools take much time compared to drawing the same in hand. Therefore, no doubt it would be a wise decision to design a technique that can accept a hand-drawn circuit diagram and serve the same purpose like that of the said tool. This initiative would not only bypass the need of such tools by non-expert users but also save the time.

Circuit component detection using image processing refers to automated separation of circuit components from hand-drawn electrical/electronic circuits. This method acts as a more productive substitution for circuit analysis than its manual counterpart. These circuits can be collected in bulk using both online and offline means. An algorithm then takes hand-drawn circuits as input and localizes the circuit components present therein. Doing so, hand-drawn circuit diagrams, being difficult to be analyzed properly, can be converted into their printed counterpart that would be easier for visualization and storing purposes. This can also be very helpful in academic purposes, like for printing machine generated circuits directly from hand-drawn ones, reducing time and human labour.

However, the procedure is not as simple as it seems to be. The segmentation of such circuit components involves several challenges owing to the difference in shapes and sizes of the circuits as well as individual circuit components. Hand-drawn circuit diagrams enhance the difficulty level manifold by increasing the number of ways a single circuit component can be drawn unlike its printed counterparts. Challenges like varying paper quality, color and quality of ink used, writing pressure may not seem of much relevance at first glance but led to major misplays when solving this by means of digital image processing based algorithms.

II. RELATED WORK

Though the complete work of segmentation of hand-drawn circuit images from document page initiated in 1990s [1], the topic received less attention from the researchers due to unstructured challenges; hence, the literature on the topic is inadequate. The complete scheme consists of various modules starting from image scanning, identifying the regions containing the components, removal of wires and finally, the localization of circuit components. Thus, a major part of this topic is an application in the field of digital image analysis.

In [2], the authors have suggested a method in which an image was pre-processed morphologically to obtain a thinned version of circuit image and then it was processed to localize the nodes and components. The nodes and components were segmented using pre-set thresholds on a