Conversion of Hand Drawn Electrical Circuit Schematics into LTSpice Format using Deep Learning Methods

Konvertierung von Handgeschriebenen Elektrischen Schaltungen in LTSpice Format mithilfe von Deep Learning Methoden

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Thesis Description

An electrical circuit schematic (ECS) is the formal way to represent an electrical circuit [QUELLE TODO]. ECSs consist of electrical circuit components, where for each electrical circuit component (ECC) a unique symbol is defined [TODO DIN]. [REMOVE For example a resistor in German notation is a rectangle.] The ECCs are connected with lines, which correspond to wires in the real world. Furthermore the ECCs are annotated with their component value. The component value is a pair of a numerical value and a string, where the string describes the unit of the component. As an example, an annotation for a resistor could be "100Ω" where "100" is the ~~value of the resistor~~ and "Ω" its unit. Additionally values of voltage or current can be associated with components. In German notation those are drawn as arrows parallel to the component, or in the latter case as arrows along the wire.

~~The knowledge of the schematic symbols, component values and the corresponding calculations, like the calculation of the voltage flow through a ECC, is taught in school and university [BEWEIS?].~~ To verify calculation results, Students rely on solutions, or on dedicated circuit simulation software (DCSS) such as LTSpice. In the latter case the hand drawn electrical circuit has to be rebuild in the application. Afterwards the ECS can be simulated to obtain the desired values. Application based approaches are considered to be ~90% TODO more time expensive, than hand drawn methods [1] [ALSO NEEDED FOR SIMULATION and additionally require a priori knowledge of the underlying DCSS]. Hence an automated method to convert a scan of an ECS into a digital format understood by a DCSS, would ~~greatly benefit the efficiency of result verification.~~

So far various researches have been conducted on the segmentation, recognition and the tracing of inter ECC connections. The proposed approaches, ~~based on the problem which they try to solve,~~ can be structured in the following way. 1) Classification of already segmented ECCs [2, 3, 4]. 2) Segmentation and classification of ECCs [5, 6]. 3) Segmentation and classification of ECCs and tracing of the wires to acquire the underlying ECS topology [7, 8]. All of the previously proposed methods performed their tasks on clean scans (white paper) of the ECCs / ECSs. ~~Although for ECS it is more common to draw on gridded paper, since it provides a visual drawing help.~~ Furthermore no method ~~has performed~~ a full conversion of the ECS into a DCSS format. The segmentation of the ECCs, through computer vision methods, as proposed ~~by~~ [5, 6, 7], can be formulated as an object detection problem. In [8] an objection detection algorithm is used for the detection and classification of logical gate components. In this thesis this approach should be applied to extract the ECCs from the ECS, drawn on white or grid paper.

This thesis aims to provide a system which is able to convert a scan of a hand drawn ECS into an intermediate format, which reflects the semantic of the ECS. The system should be agnostic to the used paper, at least considering white and grid paper. Furthermore the system should be able to recognize component annotations, which includes component values and voltage / current flow. The conversion into a DCSS format should be demonstrated on the example of LTSpice. Additionally the used methods should be chosen, such that the system could be executed on mobile hardware. Hence ~~the usage of mobile state-of-the-art deep learning methods should be preferred.~~

The thesis will comprise of the following work items:

1. Object detection of ECCs and annotations in a scan of an ECS
2. Segmentation of the ECS from the paper
3. *Postprocessing*
   (a) Building the ECS topology
   (b) Assigning annotations to corresponding ECCs
4. Embedding gathered information into a LTSpice file
5. *Optional: Mobile application*

References

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