Instance Segmentation Based Graph Extraction for Handwritten Circuit Diagram Images

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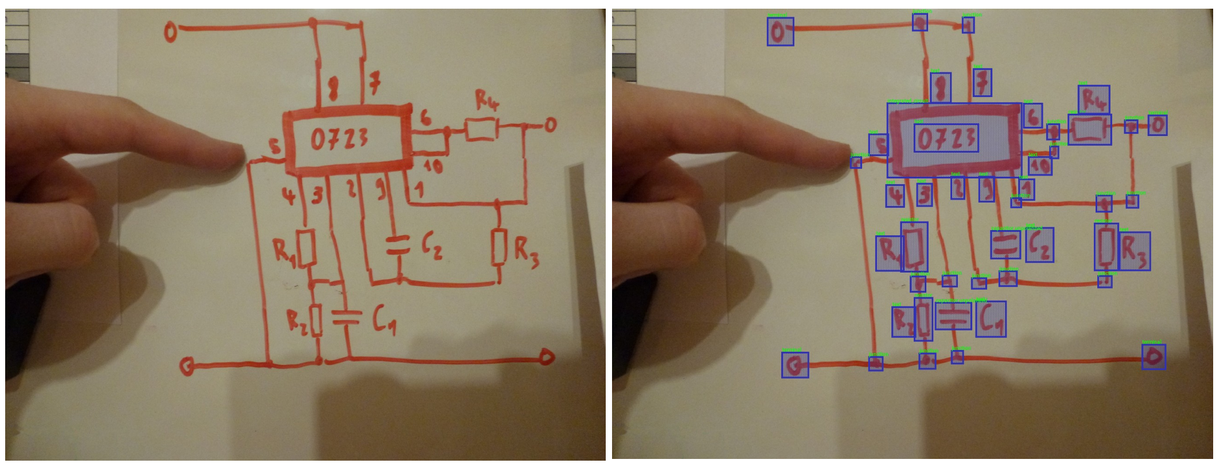
Abstract

Handwritten circuit diagrams from educational scenarios or historic sources usually exist on analogue media. For deriving their functional principles or flaws automatically, they need to be digitized, extracting their electrical graph. Recently, the base technologies for automated pipelines facilitating this process shifted from computer vision to machine learning. This work describes an approach for extracting both the electrical components (including their terminals and describing texts) as well their interconnections (including junctions and wire hops) by the means of instance segmentation and keypoint extraction and mainly focuses on a modular pipeline for preparing the training data. Consequently, the resulting graph extraction consists of a simple two-step process of model inference and trivial geometric keypoint matching. The dataset itself, its preparation, model training and post processing are described and publicly available.

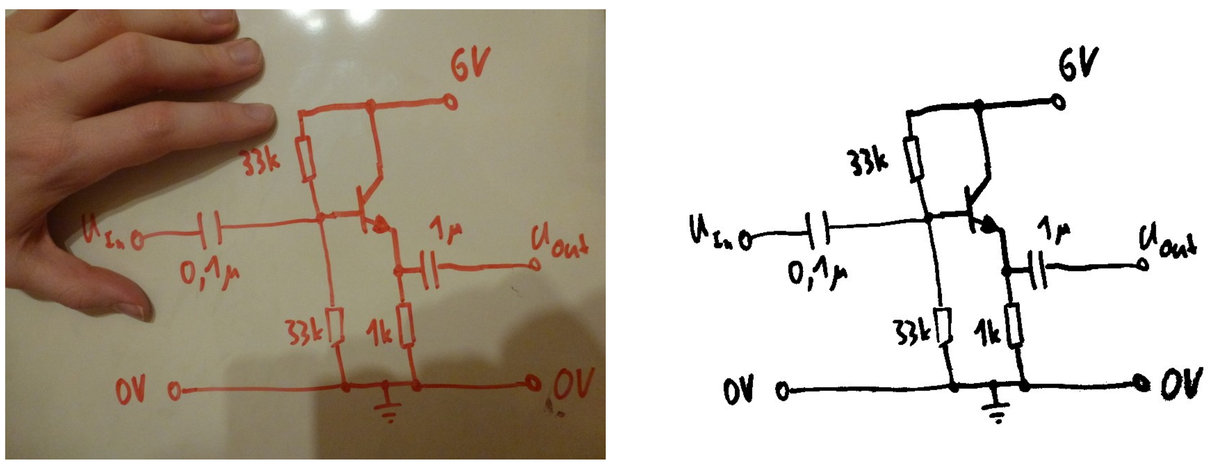
Existing Dataset

The public CGHD dataset consists of hand-drawn circuit diagram images along with bonding box annotations for electrical symbols, structural features and texts.



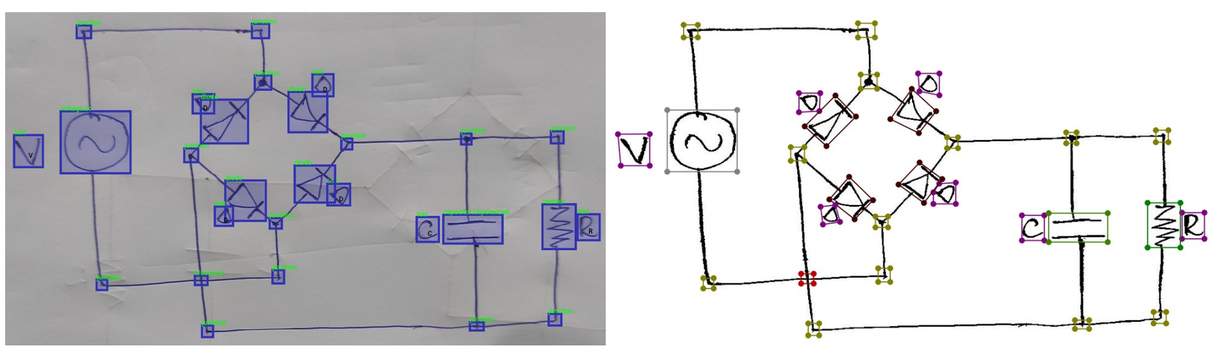
Binary Segmentation

By semi-automatic means, the drafter's pen strokes are segmented against the background.



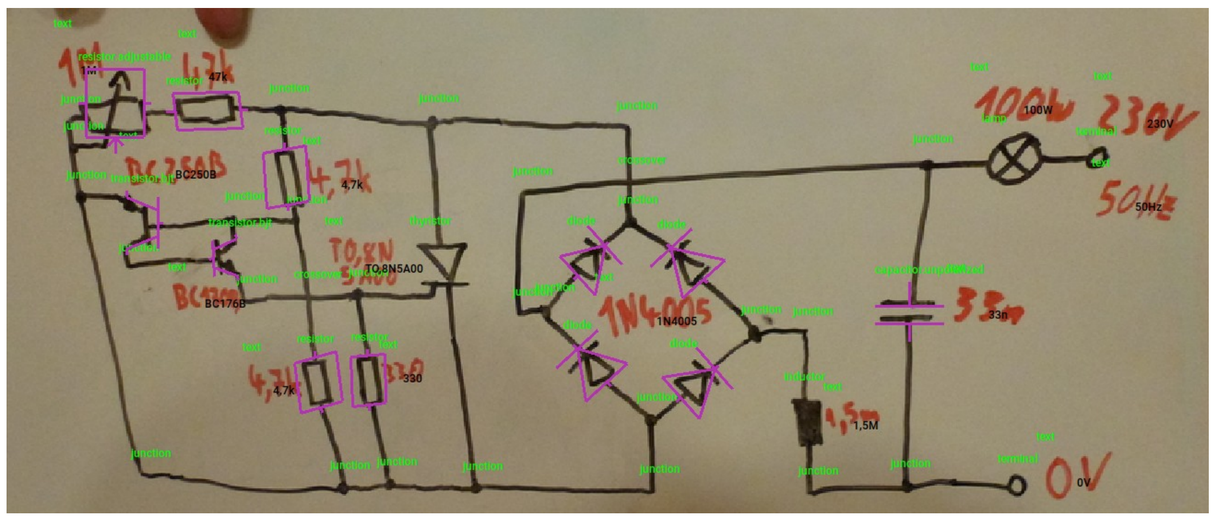
Polygon Annotation

The existing bounding boxes are automatically converted to polygons and coarsely refined to avoid overlaps between stroke annotation's stroke areas.



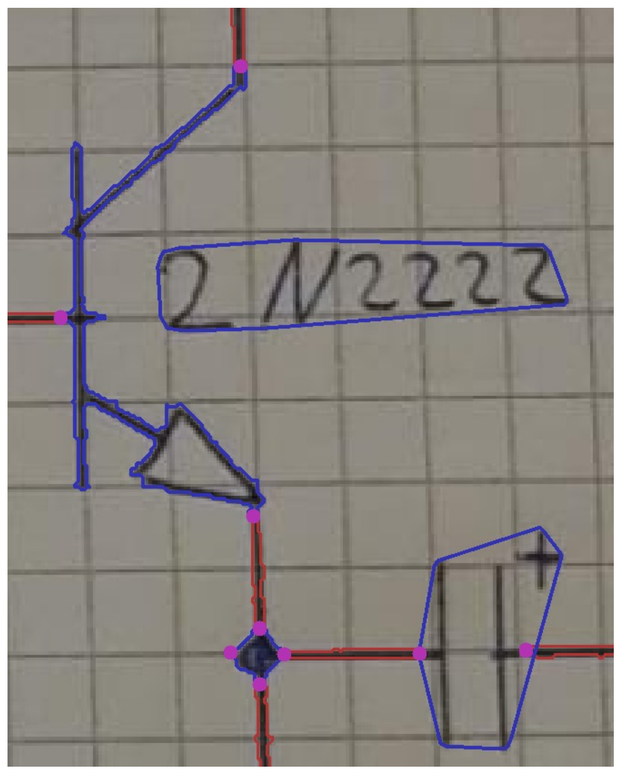
Rotation Annotation

Rotation is added to the annotations indicating the angle between the instance and a reference symbol.



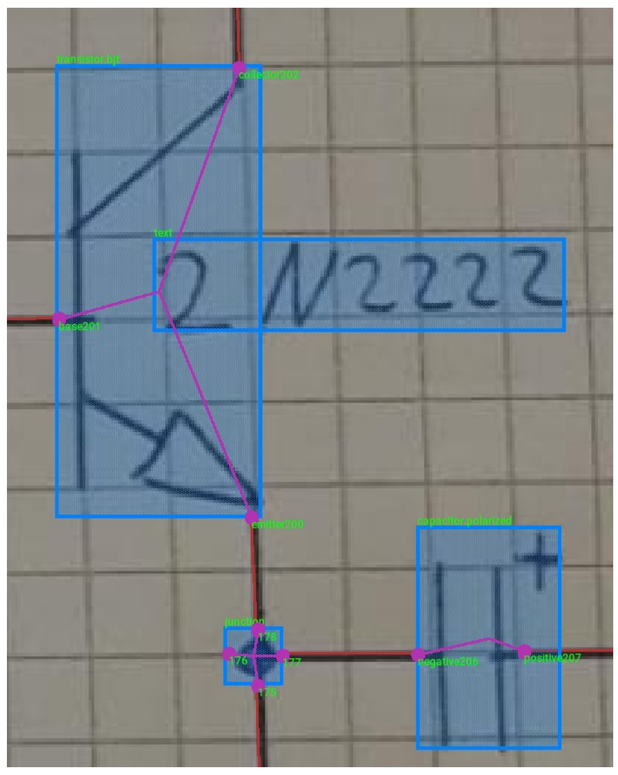
Polygon Refinement

By combining the polygon annotation and binary segmentation, a contour based refine-ment is conducted. As a side-product, polygons for describing wires are generated without any further manual overhead.



Keypoint Generation

Intersecting the borders of the coarsely refined polygons with the binary segmentation is used to determine keypoint positions. Combined with the rotation and known positions and types of connectors in the symbol reference, keypoint types are assigned.

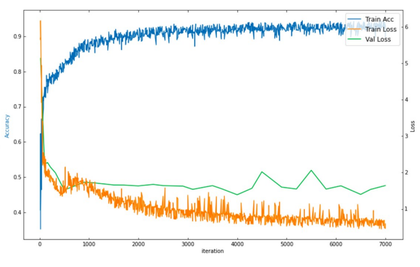


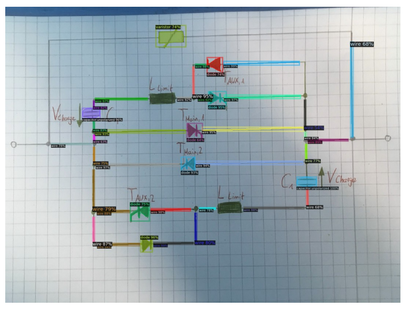
Training and Graph Structure Extraction

The resulting set of shapes and associated keypoints can now be used for instance segmentation machine learning. Graph structures can trivially be extracted from target values by matching the keypoints (→ ports) of electrical symbols (→ nodes) geometrically with the keypoints of wire shapes (→ edges).

Evaluation

By training a Mask RCNN from the torchvision implementation of the dataset, we positively validated the viability of the end-to-end approach.





Resources

https://zenodo.org/record/7547528
https://gitlab.com/circuitgraph