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Table Detection in Invoice Documents by Graph Neural Networks

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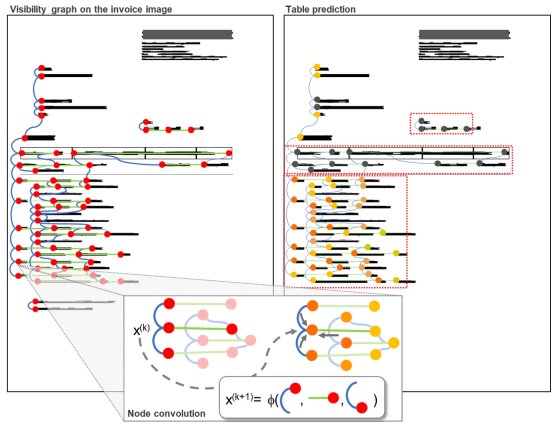
Computer Vision Center, omni:us

ICDAR, Sydney, Australia, 23rd September, 2019



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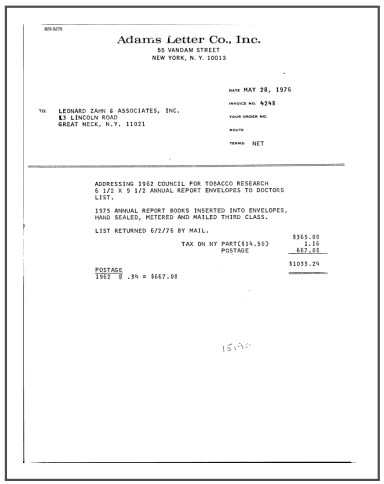
Outline

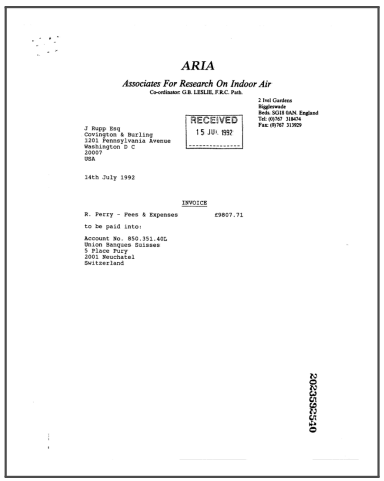
Introduction

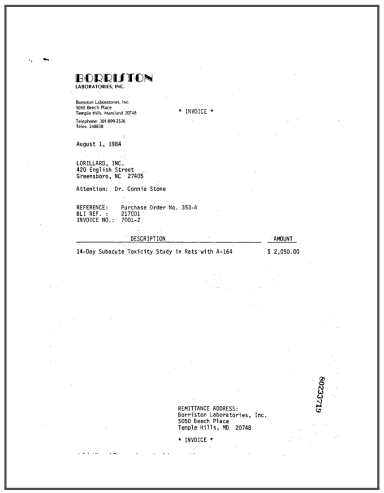
Introduction

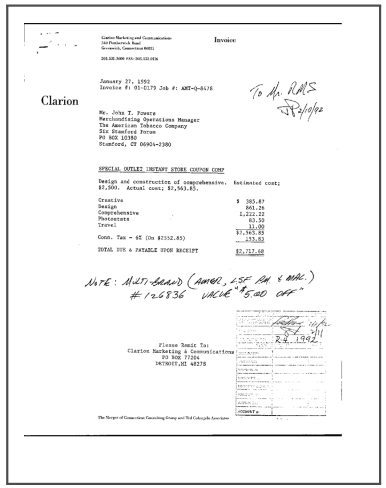
Business Documents

- **Information extraction**: Finance, insurance, manufacturing...
- **Manual extraction**: Tedious and time consuming.
- **Automatic extraction**: Reduced time and improved quality.





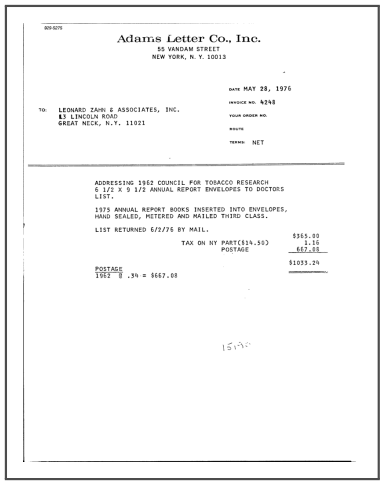


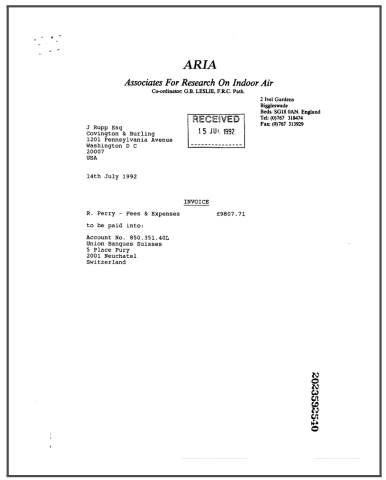


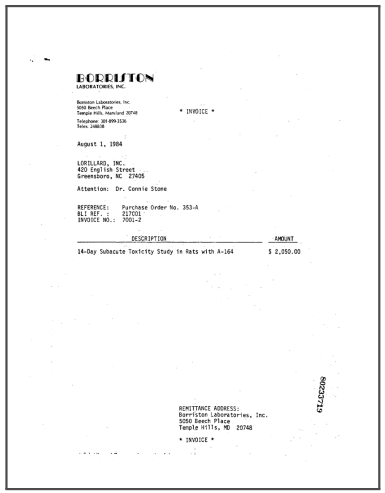
Introduction

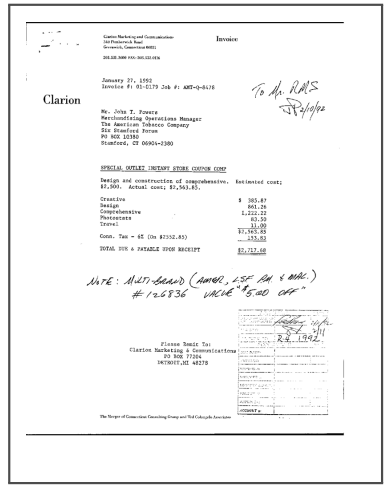
Semi-Structured Documents

- **Structured Documents**: Existing methods, high accuracy.
- **Unstructured Documents**: Human assistance and validation.
- **Semi-structured Documents**:
  - Without a fixed spatial layout.
  - Sharing a common set of components.





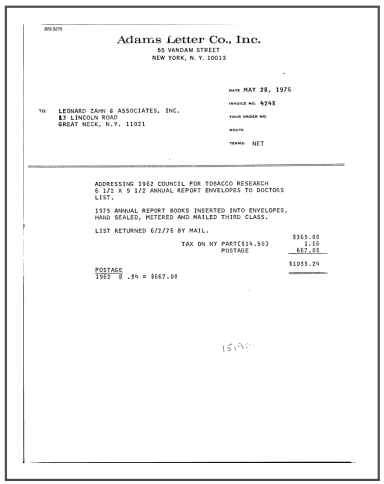


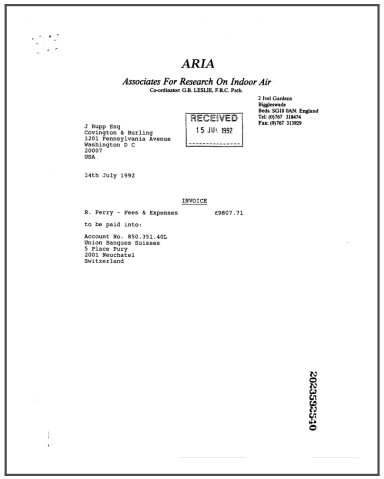


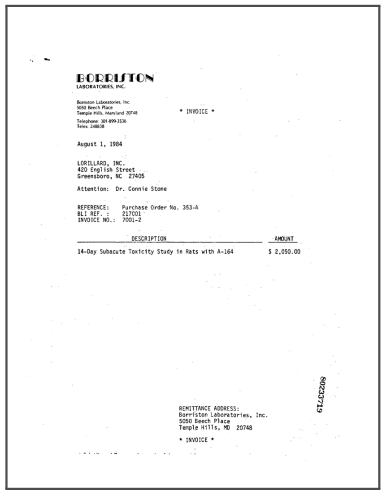
Introduction

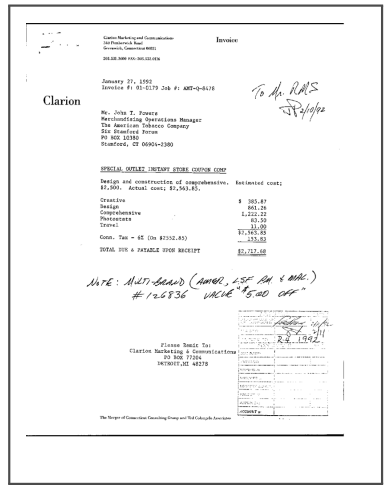
Invoice Documents

- **Semi-structured** documents with flexible layouts
- **Spatial arrangement** roughly perceived as a tabular layout
- **Tables** are commonly used to condense information





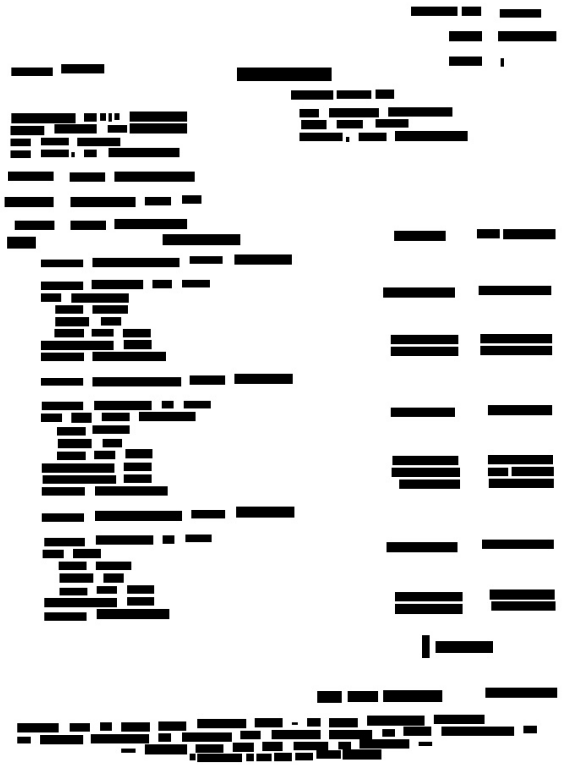




Introduction

Constraint

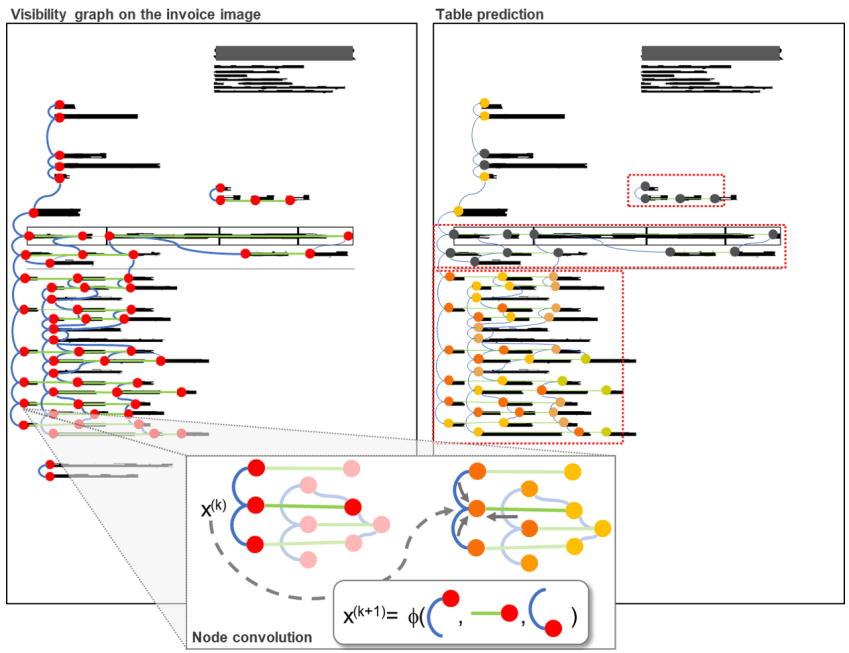
Industrial collaboration - Anonymized data



Introduction

Objective

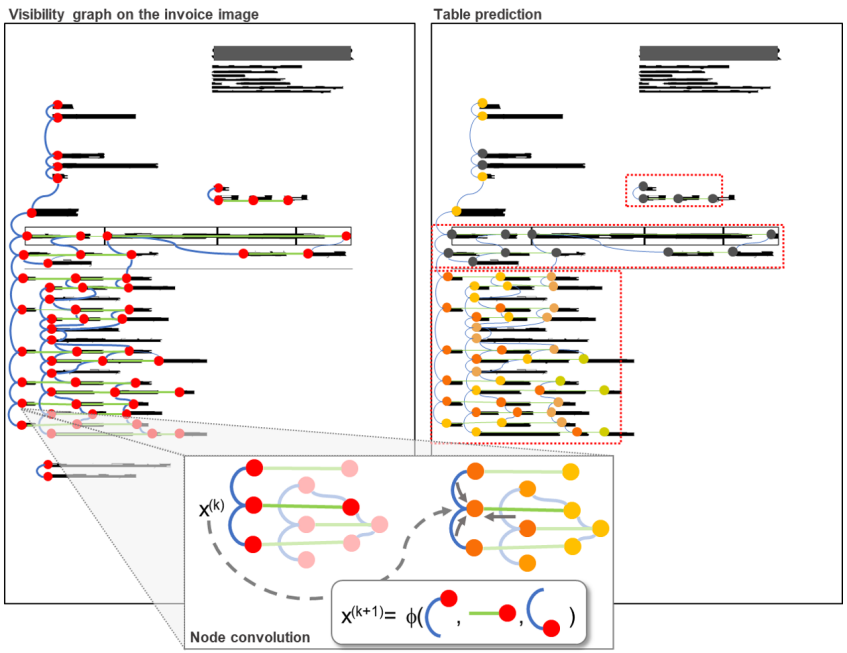
- **Graph based representation**: Exploit repetitive patterns



Introduction

Objective

- **Graph based representation**: Exploit repetitive patterns
- **Classification**: GNN classification for nodes and edges



Introduction

Objective

- **Graph based representation**: Exploit repetitive patterns
- **Classification**: GNN classification for nodes and edges
- **Table detection**: Group nodes into table regions

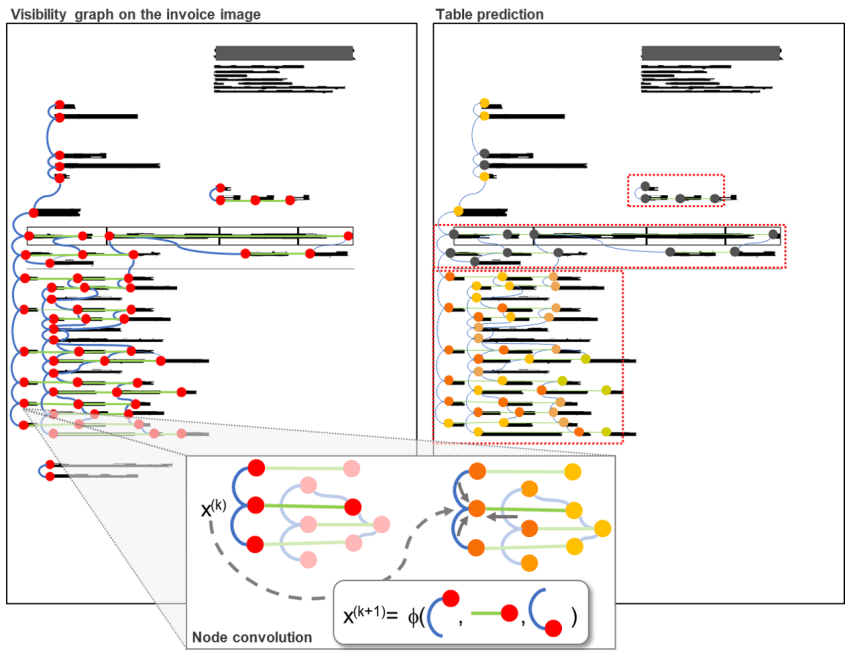
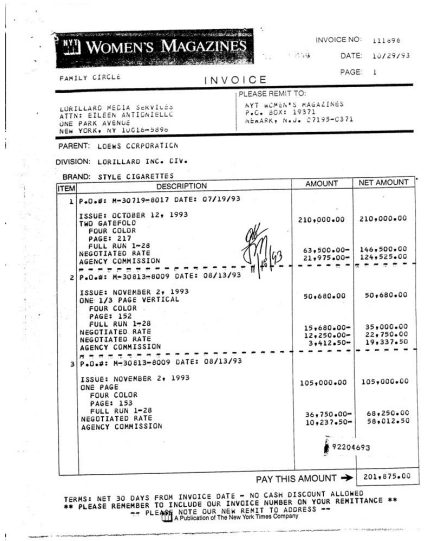
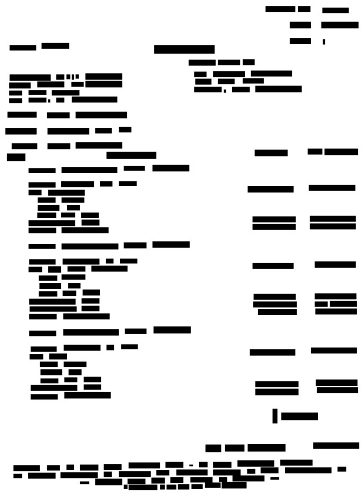


Table Detection Framework

Graph Representation

- Commercial OCR (by the industrial partner)
- Textual attributes (numeric, alphabet or symbol)
- Visibility graph:
  - Nodes: Document regions
  - Edges: Visibility relations (vertical and horizontal)





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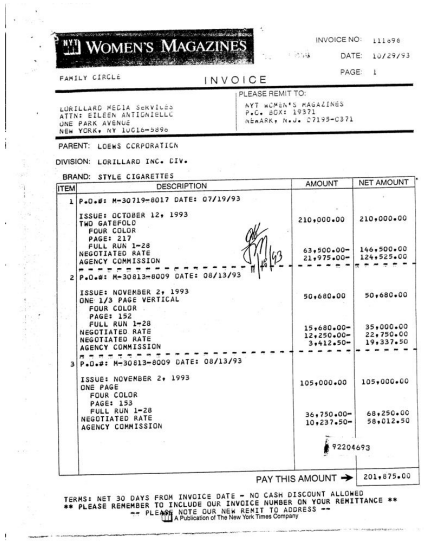
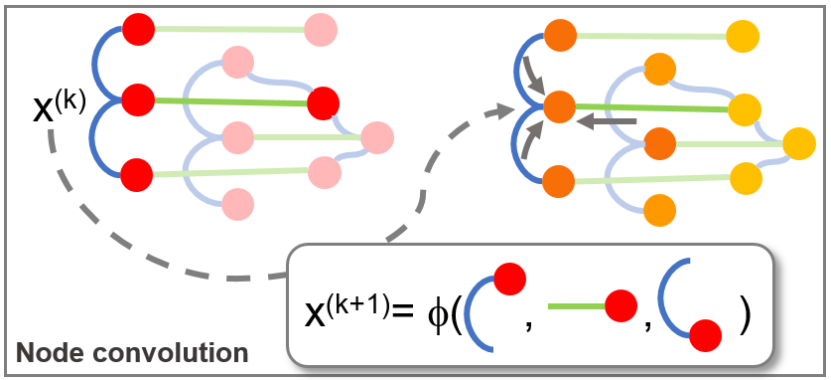


Graph Neural Network

GNN layer

- Notation introduced in [2]
- $\mathcal{A}$ - Graph intrinsic linear operators
- ρ - Activation function (ReLU)
- θ - Learnable parameters



$$x^{(k+1)} = G_C(x^{(k)}) = \rho\left(\sum_{B\in\mathcal{A}^{(k)}} Bx^{(k)}\theta_B^{(k)}\right)$$

[2] V. Garcia *et. al.*, *Few-shot learning with graph neural networks*, in ICLR, 2018.

Graph Neural Network

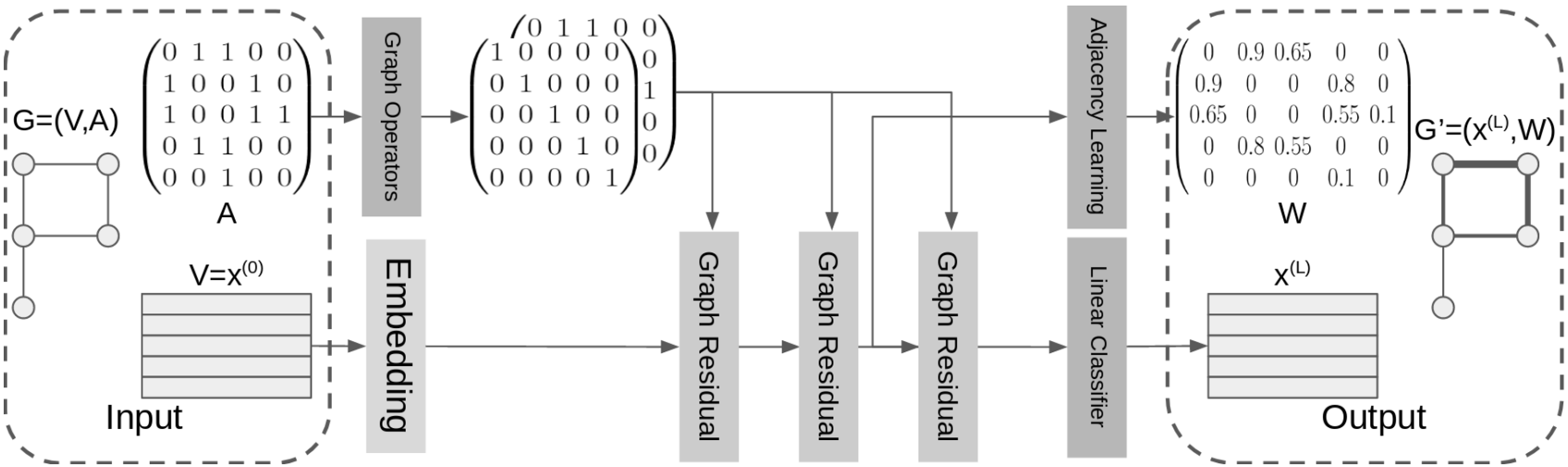
Graph Adjacency Layer

- Importance of the neighbourhood connection
- MLP - MultiLayer Perceptron
- σ - Activation function (Sigmoid)
- Absolute difference provides the symmetry property

$$\phi_k(B)_{i,j} = \begin{cases} 0 & \text{if } B_{i,j} = 0 \\ \sigma\left(\text{MLP}_{\tilde{\theta}}\left(\left|x_i^{(k)} - x_j^{(k)}\right|\right)\right) & \text{otherwise} \end{cases}$$

GNN Architecture

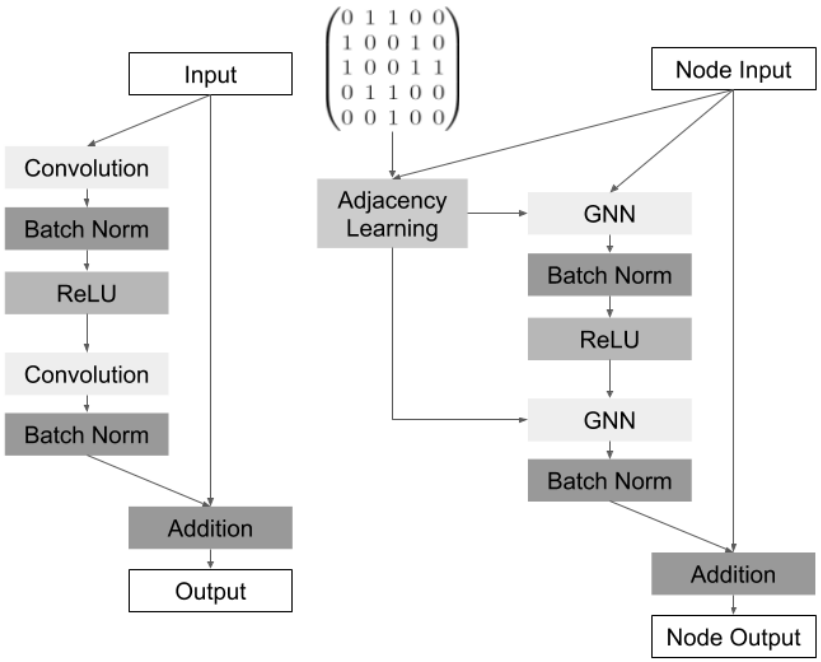
Pipeline



GNN Architecture

Graph Residual Block

- Idea of ResNet [1]
- GNN layers with a skip connection
- Edge weights are learned at the beginning of the block



[1] K. He *et. al.*, *Deep residual learning for image recognition*, in CVPR, 2016.

GNN Architecture

Objective functions

- **Node classifier:** Linear classifier with Softmax operation
- **Edge classifier:** Binary Cross entropy
  - 0 - Edge connects two different regions
  - 1 - Edge connects elements in the same region

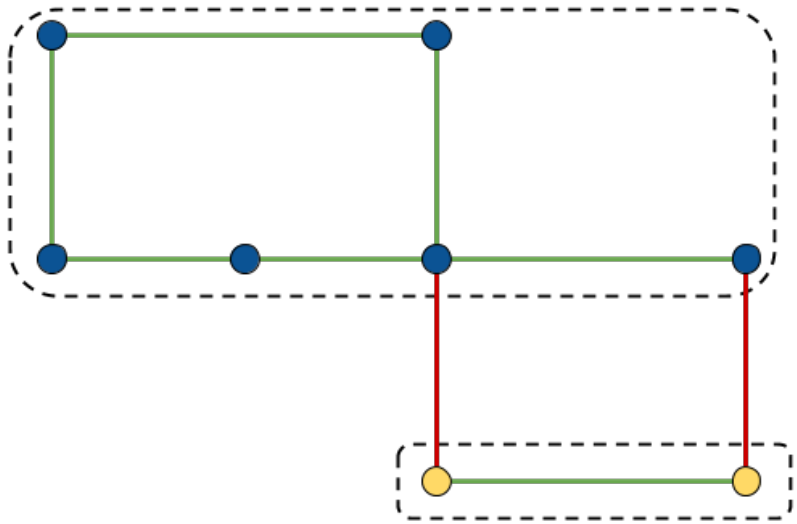
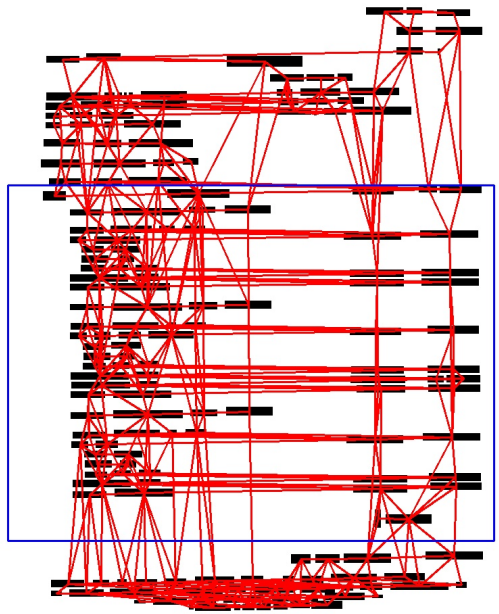


Table Detection

- Discard 0'ed edges
- Subgraphs with nodes classified as Table are considered
- The confidence score of these subgraphs are thresholded for the final decision



Experimental Validation

Datasets

CON-ANONYM

- 960 documents
- 8 region annotation
- Common car invoices
- Not publicly available

RVL-CDIP

- Overall 25,000 images
- 5 region annotation
- Selected 518 invoice class
- Publicly available [1]

[1] https://zenodo.org/record/3257319

[3] A. W. Harley *et. al.*, *Evaluation of deep convolutional nets for document image classification and retrieval,* in ICDAR, 2015.

Datasets

	CON-ANONYM	RVL-CDIP
Total # documents (tr, va, te)	950 (665, 95, 195)	518 (362, 52, 104)
Total # pages	1252	518
Total # tables	1202	485
Total # classes	8	6
Avg. # nodes/page	245.50	124.03
Avg. # edges/page	1354.81	619.55

Node/Edge Classification

Task	CON-ANONYM			RVL-CDIP		
	All	Table	Edge	All	Table	Edge
Pow 2	82.8	96.4	–	57.8	80.9	–
+ Edge	84.2	97.0	93.4	58.2	79.1	84.1
Pow 5	82.7	96.2	–	56.5	82.3	–
+ Edge	84.5	97.2	93.4	62.3	83.9	84.0

Table Detection

- Intersection over Union

Task	CON-ANONYM			RVL-CDIP		
	F1-Score	Precision	Recall	F1-Score	Precision	Recall
Pow 2	69.4	65.8	73.4	28.6	23.9	35.4
+ Edge	70.8	65.2	77.6	30.8	26.7	36.5
Pow 5	68.4	65.3	71.8	22.6	20.0	26.0
+ Edge	73.7	78.4	69.5	30.8	25.2	39.6

Table Detection

- Proper detection

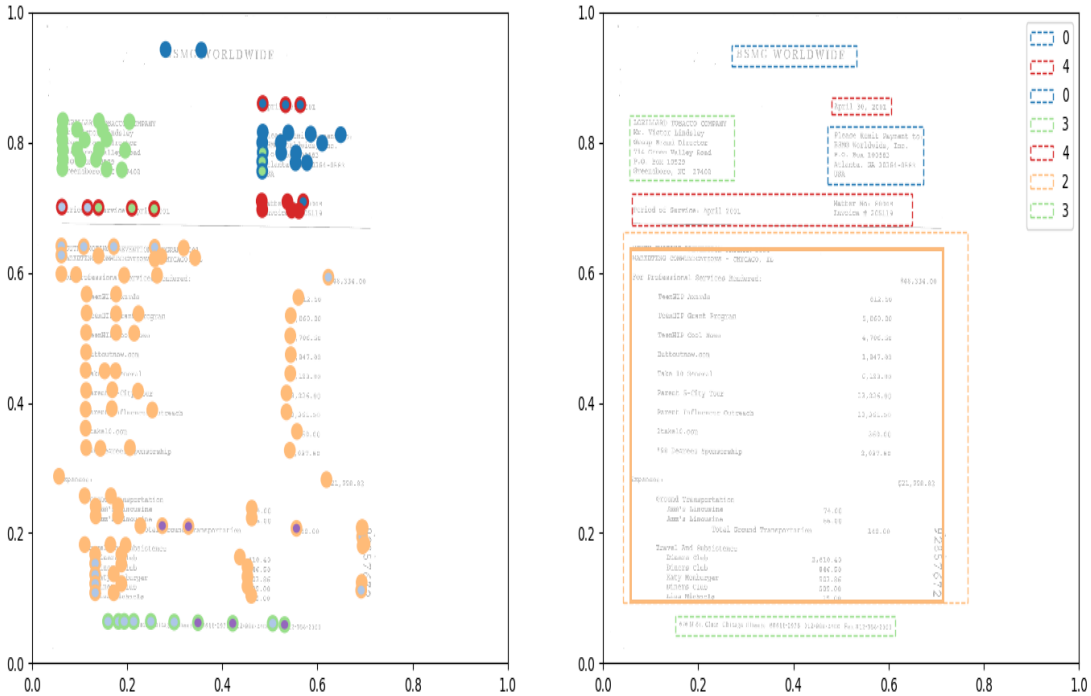


Table Detection

- Proper detection

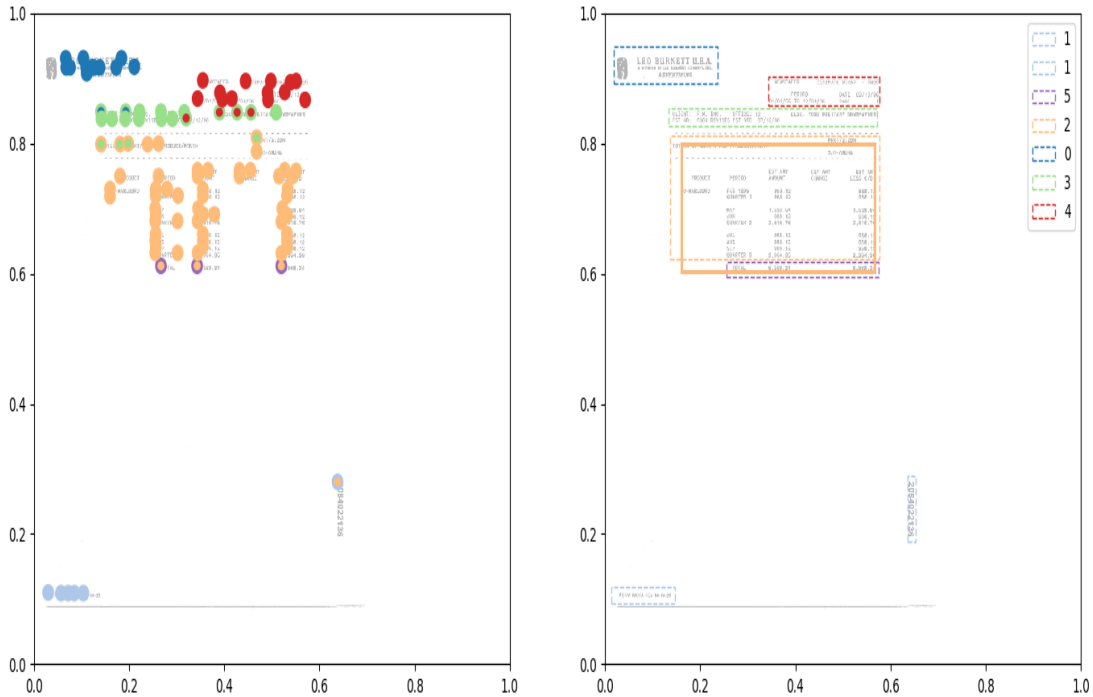


Table Detection

- Proper detection
- Preprocessing problems

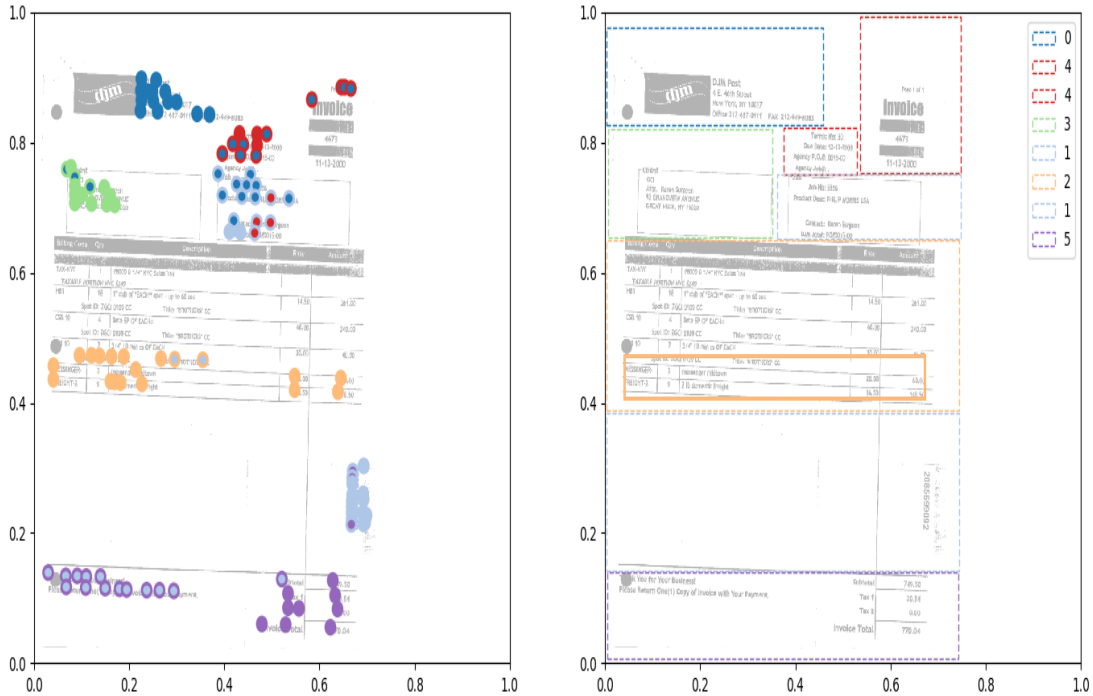
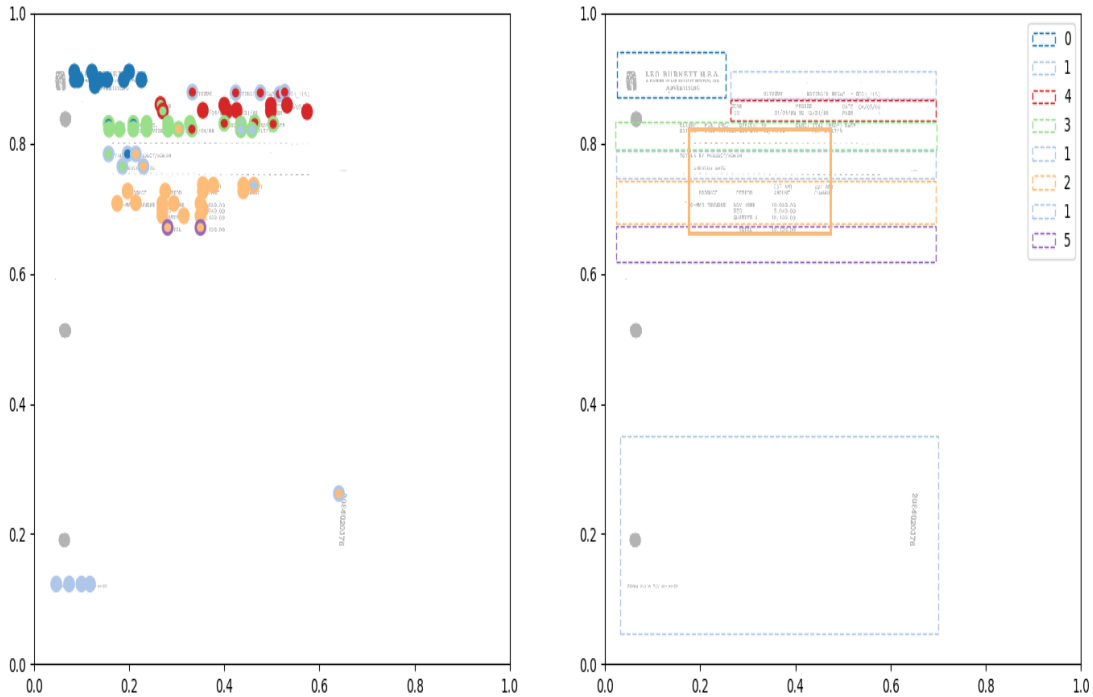


Table Detection

- Proper detection
- Preprocessing problems
- Tabular layout



Conclusions and Future Work

Conclusions and Future Work

- First *Table Detection* based on structural information.
- A Graph models the underlying structure of the document.
- Publicly available RVL-CDIP invoice dataset.
- Deal with anonymized data.

- Generalize to unconstrained tabular layout.

Thank you for your attention!

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