





## CDeC-Net: Composite Deformable Cascade Network for Table Detection in Document Images



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## Problem Statement

- Detect tables in document images with high accuracy
- Single trained model for wide variety of documents
- Uniform benchmarking across various publically available datasets

## Challenges

→ High degree of intra-class variability due to different layouts of the table and inconsistent use of ruling lines.

No.	1 - 2	1 - 3	1 - 4	1 - 5 - 1	- 6	Av. Raw	$\sigma$ Raw	Av. Cor.	$\sigma$ Cor.
Veh.						Matches	Matches	Matches	Matches
1000	10					111.4	8.5	11.4	8.5
2000	10					411.8	19.5	11.8	19.5
1000	100					199.2	12.0	99.2	12.0
1000	200					302.3	7.7	202.3	7.7
1000	500					596.6	12.3	496.7	12.3
1000	0	10				21.9	4.6	9.3	3.3
1000	500	10				73.8	7.5	10.2	6.2
1000	100	100				152.1	8.5	101.9	7.5
1000	500	250				388.3	22.7	253.2	20.1
1000	0	500				667.2	24.9	506.0	22.3
1000	0	0	100			154.6	26.6	104.0	22.6
1000	100	100	100			164.4	11.4	97.7	9.3
500	100	100	100			140.7	19.3	105.8	17.4
1000	500	250	100			207.8	29.7	106.1	23.7
500	10	10	10	10		14.2	2.2	10.5	1.8
1000	10	10	10	10		17.4	4.1	9.4	2.8
500	50	50	50	50		71.3	14.3	47.8	12.3
500	100	100	100	100		151.9	26.9	92.0	22.3
1000	0	0	0	100		177.6	29.9	103.4	22.6
1000	100	100	100	100		222.2	61.5	111.0	46.7

HTTP Server Software	RedHat Lir	ux 7.1; Apache 1.3.14
	jackanapes	SUN Ultra-10: 440MHz M UltraSPARC- e B Ili processor m
HTTP Client Hardware	jacobi	with 2-MB o external cache, r DRAM with speed of 50ns b 64 r M B
	jabberwock	SUN Ultra-2 with 300MHz CPU and 128MB memory
HTTP Client Software	Sun OS F X1	Release 5.8, CDE1.4, I Version 6.4.1

### Challenges

- → High degree of intra-class variability due to different layouts of the table and inconsistent use of ruling lines.
- Close resemblance of graphs, flowcharts, figures having large number of horizontal and vertical lines to table creates inter-class similarity.

$$\boldsymbol{\alpha}''(k) = \begin{bmatrix} \alpha_{11}''(k) & \alpha_{12}''(k) & \alpha_{13}''(k) & \alpha_{14}''(k) \\ \alpha_{21}''(k) & \alpha_{22}''(k) & \alpha_{23}''(k) & \alpha_{24}''(k) \\ \alpha_{31}''(k) & \alpha_{32}''(k) & \alpha_{33}''(k) & \alpha_{34}''(k) \\ \alpha_{41}''(k) & \alpha_{42}''(k) & \alpha_{43}''(k) & \alpha_{44}''(k) \end{bmatrix}$$



### Challenges

- → High degree of intra-class variability due to different layouts of the table and inconsistent use of ruling lines.
- → Close resemblance of graphs, flowcharts, figures having large number of horizontal and vertical lines to table created inter-class similarity.
- → Different researchers have used different methods for benchmarking.
- → Noisy detections at higher IoU thresholds

### **Our Approach: CDeC-Net**

### **CDeC-Net Architecture**



### **Composite Backbone**



### **Deformable Convolution**



### **Cascade Network**



### **CDeC-Net Architecture**



### **Quantitative Results**

Dataset	Method	Precision	Recall	F1	mAP
ICDAR-2013	DeCNT	0.996	0.996	0.996	-
	CDeC-Net	1.000	1.000	<b>1.000</b>	1.000
ICADR-2017	Yolov3	<b>0.968</b>	<b>0.975</b>	<mark>0.971</mark>	-
	CDeC-Net	0.924	0.970	0.947	0.912
ICADR -2019	TableRadar	<b>0.940</b>	0.950	<b>0.945</b>	-
	CDeC-Net	0.934	0.953	0.944	0.922
UNLV	GOD	0.910	0.946	0.928	-
	CDeC-Net	<b>0.925</b>	0.952	<b>0.938</b>	0.912
Marmot	DeCNT	<b>0.946</b>	0.849	0.895	-
	CDeC-Net	0.930	0.975	<b>0.952</b>	0.911
TableBank	Li et al.	0.975	0.987	0.981	-
	CDeC-Net	<b>0.979</b>	<b>0.995</b>	<b>0.987</b>	0.976
PubLayNet	M-RCNN CDeC-Net	- 0.970	0.988	- 0.978	0.960 <b>0.967</b>

### Quantitative Results: CDeC-Net Model

Dataset	Method	Precision	Recall	F1	mAP
ICDAR-2013	DeCNT	<b>0.996</b>	<b>0.996</b>	<b>0.996</b>	-
	CDeC-Net‡	0.942	0.993	0.968	0.942
ICADR-2017	Yolov3	0.968	<b>0.975</b>	<b>0.971</b>	-
	CDeC-Net‡	0.899	0.969	0.934	0.880
ICADR -2019	TableRadar	<b>0.940</b>	0.950	0.945	-
	CDeC-Net‡	0.930	<b>0.971</b>	<b>0.950</b>	0.913
UNLV	GOD	0.910	0.946	0.928	-
	CDeC-Net‡	<b>0.915</b>	<b>0.970</b>	<b>0.943</b>	0.912
Marmot	DeCNT	<b>0.946</b>	0.849	<b>0.895</b>	-
	CDeC-Net <sup>‡</sup>	0.779	<b>0.943</b>	0.861	0.756
TableBank	Li et al.	<b>0.975</b>	0.987	<mark>0.981</mark>	-
	CDeC-Net‡	0.970	<b>0.990</b>	0.980	0.965
PubLayNet	M-RCNN CDeC-Net‡	0.975	- 0.993	0.984	0.960 0.978

### Quantitative Results: Single CDeC-Net Model

### **Qualitative Results**



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Qualitative Results: CDeC-Net accurately detects tables





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#### Statement of Consolidated Financia' Position

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ABBETS	1993		
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Cash and cash equivalents	\$ 275	8: 729	
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la semilerada.	1.224	1.356	
TOTAL CURRENT ABSETS	3,672	6.060	
PROPERTY, PLANT AND EQUIPMENTS			
Land	107	106	
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### **Qualitative Results: CDeC-Net fails to detects tables**

#### FY18 Inancial performance

#### Key financial metrics

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Qualitative Results: Primary CDeC-Net fails whereas Single CDeC-Net\* detects table accurately.

ries by topic	NVIDIA CORPORATION CONDENSED CONSOLIDATED BALANCE SHEETS (In millions) (In millions)				Particle	Instantion         TABLE 1         Constant           Price         Marce         Marce         (Mr. Ar )         Marce         Marce           Price         Marce
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Anadom and Security 140 mer i Freed safate / Nebic Asakh 120	Land Frenzen and Houry	Cash, cash equivalents and marketable socurities Accounts receivable, net Inventories Proposit expenses and other current assets	\$ 7,591 2,219 1,417 159	\$ 7,105 1,265 796	D1 27-3         D17 26-5         NOP         OSE         PER         D1           01 27-5         NOP         <	10:100:
I retain and involution I retained and involution Interference (South 70)	Exempt endations and involutiones	Total current assets Property and equipment, net	11,386	9,255	MD 100         MD 100         MD 100         MD 100         MD 101         MD 100         MD 100<	ID-1047         ID-1076         NOA         ID-1067         NOA         ID-1076         NOA         ID-1076         NOA         ID-1076         NOA         ID-1076         NOA         ID-1076         ID-1076         NOA         NOA         ID-1076         ID-1076         NOA         NOA         ID-1076         ID-1076         NOA         NOA         ID-1076         ID-1076         NOA         ID-1076         ID-1076         NOA         ID-1076         ID-1076         NOA         NOA         ID-1076         ID-1076         NOA         NOA         ID-1076         NOA         NOA         ID-1076         NOA         NOA <th< td=""></th<>
s and taxation the		Goodwill Intangible assets, net Other assets Total assets	618 49 312 5 13,852	610 52 319 11,241	Diffusion         Diffusion         State         Total	ID 1774 J.         ID 1774 J.         ID 1784 J.         ID 1884
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palicy, tofowrance locary and mode, Caluer, c and monetary affairs, Reacards and innovation, and maintime affairs, Internal Market and services		Current Tablities: Accounts payable Accrued and other current liabilities Convertible short-term debt	\$ 902 705 3	\$ 596 542 15	D 0000         M 20001         M 20001 <thm 20001<="" th=""> <thm 20001<="" th=""> <thm< td=""><td>Instance         UP rate         PRF         Loss         RT           Instance         UP rate         PRF         Loss         RT</td></thm<></thm></thm>	Instance         UP rate         PRF         Loss         RT
explipitencie tim		Total current liabilities Long-term debt	1,608 1,907 507	1,153	D.0         M.0         M.0 <thm.0< th=""> <thm.0< th=""> <thm.0< th=""></thm.0<></thm.0<></thm.0<>	Instant         Instant <t< td=""></t<>
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n, vegant for particle details and response for an and an and an and an and an and an and an an an an an an and an		Total liabilities and shareholders' equity	\$ 13,657	\$ 11,241		ID:1         ID:2         ID:2 <thid:2< th="">         ID:2         ID:2         <thi< td=""></thi<></thid:2<>

Qualitative Results: Single CDeC-Net\* fails whereas primary CDeC-Net detects table accurately

## **Effect of IOU**

IoU		Performance on Various Benchmark Datasets											
Threshold	ICDAR-2013			IC	DAR-2	019	UNLV						
	R↑	P↑	F1↑	R↑	P↑	F1↑	R↑	P↑	F1↑				
0.5	1.000	1.000	1.000	0.946	0.987	0.966	0.770	0.960	0.865				
0.6	1.000	1.000	1.000	0.939	0.980	0.959	0.758	0.944	0.851				
0.7	0.987	0.987	0.987	0.936	0.977	0.956	0.734	0.915	0.825				
0.8	0.942	0.942	0.942	0.930	0.971	0.950	0.663	0.826	0.744				
0.9	0.660	0.660	0.660	0.895	0.934	0.915	0.496	0.618	0.557				



### **Conclusion and Future Work**

- → CDeC-Net achieves state-of-the-art results for table detection.
- → The architecture can be extended to other page objects such as Figures, Title, Logos, Mathematical Expressions etc.
- → CDeC-Net can be extended to tackle more challenging problem of Table Structure Recognition

### **Questions?**

# **Thank You**