Extract Text from Receipts using Deep Vision

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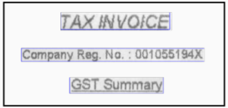
Text Extraction Pipeline

Our Focus

Extract Receipt from Background

Detect Bounding Boxes

Input for Text Recognition



Text Recognition

TAX INVOICE

Company Reg. No. : 001055194X

GST Summary

HON HWA HARDWARE TRADING
COMPANY REG. NO. : 001055194X
NO 37, JALAN MANIS 7, TAMAN SEGAR
56100 CHERAS, KUALA LUMPUR.
+603-9130 2672
GST REG : 001125220352
TAX INVOICE
CB# : 87870 21/09/2017 10:20:37 AM
M# : C2 - 0
CASHIER CASH1 -
QTY DESCRIPTION PRICE TOTAL(RM)
0.9 3/4" ALUMINIUM ROD 6.00 5.40 SR
5 PVC WALLPLUG 1.00 5.00 SR
(50PCS)
5.9 TYPE: 2 TOTAL 10.40
DISCOUNT: 0.00
ROUNDING ADJ 0.00
TOTAL INCLUSIVE GST: 10.40
CASH 10.40
GST SUMMARY
CODE % NET AMT GST TOTAL(RM)
SR SR 9.81 0.59 10.40
TOTAL 9.81 0.59 10.40
THANK YOU ! & PLEASE COME AGAIN !!
GOODS SOLD ARE NOT RETURNABLE FOR
REFUND OR EXCHANGE !!

Important Information Extraction

Name of Store
Purchased Items
Total Price

Text Detection

- First step is to localize text → bounding boxes
- Receipts with annotated bounding boxes as training data
- Detected bounding boxes as input for text recognition

Figure 1: Bounding boxes used for training.

EAST-Model: Architecture

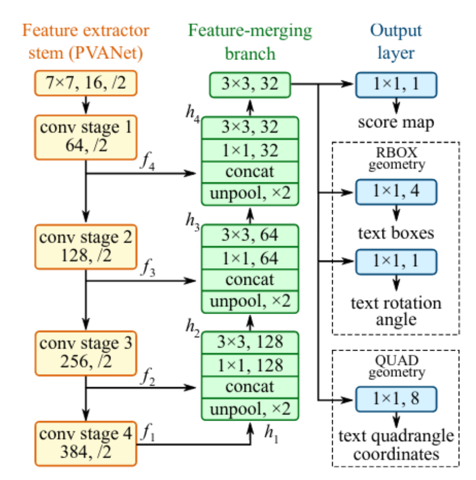


Figure 2: Architecture of the EAST-Network [6].

- EAST: Efficient and Accurate Scene Text Detector by Zhou *et al.* (2017)[6]
- Fully Convolutional Architecture
- Pre-trained classification net (VGG16) for feature extraction
- U-shaped design to merge features from different levels and keep computational cost small
- Loss function $L = L_{score} + L_{geo}$

EAST-Model: Loss function

Score Loss

- Score map S with value of 1 for every pixel inside bounding box
- Dice score for loss

$$L_{score} = 1 - \frac{2|S_{pred} \cap S_{true}|}{|S_{pred}| + |S_{true}|}$$

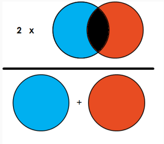


Figure 3: Illustration dice loss [4].

Geometry Loss

- Geometry map G storing offset to four corners for every pixel inside a box:
  $$G_i = \{x_1, x_2, \cdots, x_8\} \in G$$
- Loss

$$l_i = \sum_{i=1}^{8} \frac{\text{smoothed}_{\text{L1}}(x_i - \hat{x}_i)}{\text{shortest edge}}$$

$$L_{geo} = \frac{1}{N} \sum_{i=1}^{N} l_i \qquad \text{with N pixels}$$

$$\text{smoothed}_{L_1}(x) = \begin{cases} 0.5x^2 & \text{if } |x| < 1 \\ |x| - 0.5 & \text{otherwise} \end{cases}$$

Data set Text Detection

Data provided by:

ICDAR 2019 Robust Reading Challenge on Scanned Receipts OCR and Information Extraction

- Data set: 986 receipts in english
- Annotation: Bounding boxes and text
- 626 training images and 360 test images

Results Text Detection

- Best IoU score of 81.86%

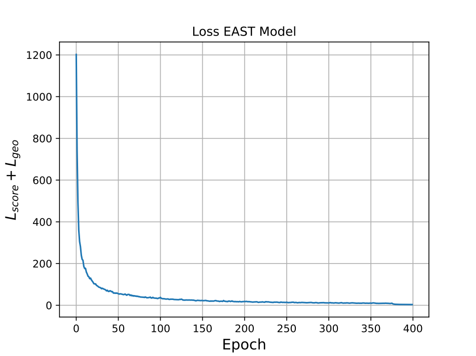


Figure 4: Loss after different number of epochs.

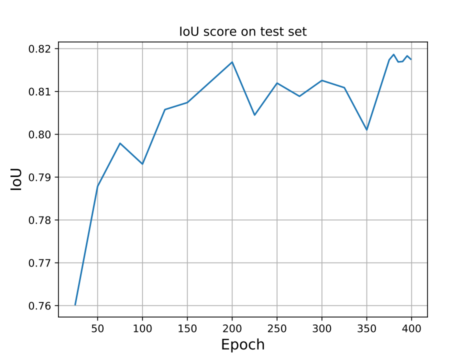


Figure 5: Intersection over Union.

Results Text-Detection - Example

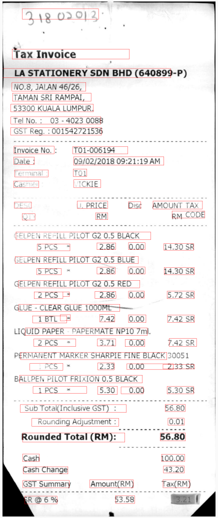


Figure 6: Text detection on test data.

Figure 7: Text detection on test image.

Text-Recognition

- Use ground truth bounding boxes for training
- Crop bounding boxes and scale as preprocessing
- Different approaches have been tested:
    - CRNN
    - DenseNet + RNN + CTC
    - DenseNet + CTC
    - Adding artificial data for training
    - Different CTC input lengths (32 and 64)

Figure 8: Example of text recognition.

Connectionist Temporal Classification (CTC) - Encoding

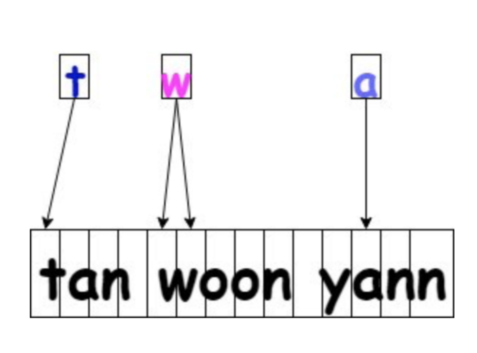


Figure 9: Text encoding mechanism for CTC Loss [2].

- Characters can span over multiple lines
- Introduce blank "-" character to encode duplicate characters (removed in decoding)

Examples:

"aa" $\rightarrow$ "a-a"

"a" $=$ "-a" $=$ "a- -" $=$ "aaa"

$\rightarrow$ different alignments represent same text

CTC Loss - Calculation

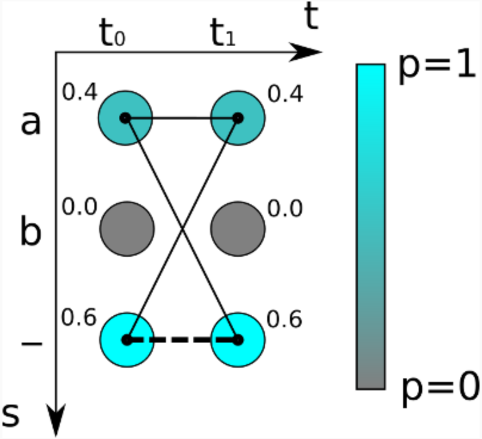


Figure 10: Example CTC Loss calculation [3].

- Output Net: Score for every character for every slot/time step
- Score: Sum output for all possible alignments of ground truth text

Example for ground truth : "a"

Possible alignments: "-a", "a-", "a"

Score: $0.4 \cdot 0.6 + 0.6 \cdot 0.4 + 0.4 \cdot 0.4 = 0.64$

$\rightarrow$ Maximize score

Data set Text Recognition

- Cropped bounding boxes for training
- 33626 images as training set
- Additionally create artificial images with data generator [1].

Results Text Recognition - Comparison of different Models

- Word Accuracy: Number of correctly predicted words/sentences
- Levenshtein Score: Similarity depending on number of character differences

	Dense Net 32	Dense Net 64	CRNN 32	CRNN 64	Tesseract
CTC Loss	0.0025	0.0059	0.1332	0.0147	–
Word Accuracy	57.6%	64.2%	54.8%	66.3%	53.6%
Levenshtein Score	85.6%	93.3%	88.4%	93.4%	90.0%

Table 1: Quantitative results of the different methods.

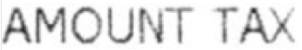
Result Text Recognition - Examples

Correct Predictions

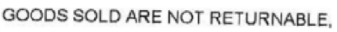
TAX INVOICE

53300 KUALA LUMPUR.

AMOUNT TAX

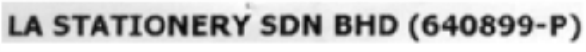


GOODS SOLD ARE NOT RETURNABLE,



Wrong Predictions

LA STATIONERY SDN BHD (G40899-P)



NOE (7 IDCATED THE ITEM SOLD HAS BEEN RELAED

PERMAIET MARKCR SHARPE FNE BLAK 001

CASHNIEOY :

0. PRICE

Results Text Recognition - Example Complete Receipt

318 02013

Tax Invoice

LA STATIONERY SDN BHD (640899-P)
NO.8, JALAN 46/26,
TAMAN SRI RAMPAI,
53300 KUALA LUMPUR.
Tel No. : 03 - 4023 0088
GST Reg. : 001542721536

Invoice No. : T01-006194
Date : 09/02/2018 09:21:19 AM
Terminal : T01
Cashier : VICKIE

DESC U. PRICE Disc AMOUNT TAX
QTY RM RM CODE

GELPEN REFILL PILOT G2 0.5 BLACK
5 PCS * 2.86 0.00 14.30 SR
GELPEN REFILL PILOT G2 0.5 BLUE
5 PCS * 2.86 0.00 14.30 SR
GELPEN REFILL PILOT G2 0.5 RED
2 PCS * 2.86 0.00 5.72 SR
GLUE - CLEAR GLUE 1000ML
1 BTL * 7.42 0.00 7.42 SR
LIQUID PAPER - PAPERMATE NP10 7ml.
2 PCS * 3.71 0.00 7.42 SR
PERMANENT MARKER SHARPIE FINE BLACK 30051
1 PCS * 2.33 0.00 2.33 SR
BALLPEN PILOT FRIXION 0.5 BLACK
1 PCS * 5.30 0.00 5.30 SR

Sub Total(Inclusive GST) : 56.80
Rounding Adjustment : 0.01
Rounded Total (RM): 56.80

Cash 100.00
Cash Change 43.20
GST Summary Amount(RM) Tax(RM)
SR @ 6 % 53.58 3.21

True text

TAX INVOICE
LA STATIONERY SDN BHD (640899-P)
NO.8, JALAN 46/26,
TAMAN SRI RAMPAI.
53300 KUALA LUMPUR.
TEL NO. : 03-4023 0088
GST REG. : 001542721536
INVOICE NO. : T01-006194
DATE: 09/02/2018 09:21:19AM
TERMINAL : T01
CASHIER : VICKIE
DESC U. PRICE DISC AMOUNT TAX
QTY RM RM CODE
GELPEN REFILL PILOT G2 0.5 BLACK
5 PCS * 2.86 0.00 14.30 SR
GELPEN REFILL PILOT G2 0.5 BLUE
5 PCS * 2.86 0.00 14.30 SR
GELPEN REFILL PILOT G2 0.5 RED
2 PCS * 2.86 0.00 5.72 SR
GLUE - CLEAR GLUE 1000ML
1 BTL * 7.42 0.00 7.42 SR
LIQUID PAPER - PAPERMATE NP10 7ML.
2 PCS * 3.71 0.00 7.42 SR
PERMANENT MARKER SHARPIE FINE BLACK 30051
1 PCS * 2.33 0.00 2.33 SR
BALLPEN PILOT FRIXION 0.5 BLACK
1 PCS * 5.30 0.00 5.30 SR
SUB TOTAL(INCLUSIVE GST) : 56.80
ROUNDING ADJUSTMENT : 0.01
ROUNDED TOTAL (RM): 56.80
CASH 100.00
CASH CHANGE 43.20
GST SUMMARY AMOUNT(RM) TAX(RM)
SR @ 6% 53.58 3.21

Predicted Text

TAX INVOICE
LA STATIONERY SDN BHD (G40899-P)
NO.8, JALAN 46/26,
TAMAN SRI RAMPAI,
53300 KUALA LUMPUR.
TEL NO. : 03 -4023.0088
GST REG. : 001542721536
INVOICE NO. : TO01-006194
DATE : 09/02/2018 09:21:19 AM
TER MINAL : T01
CASHNIEOY : /ICKIE
DES0 0. PRICE DISC AMOUNT TAX
QT / RM RM CODE
GELPEN REHIUL PILOT G2 0.5 BACK
5.PCS * 2.86 0.00 14.30 SR
GEUPEN REFILL PILOT G2 0.5 BLUE
5 PCS * 2.86 0.00 14.30 SR
GELPEN REHILL PILOT G2 0.5 RED
2 PCS E X 2.86 0.00 5.72 SR
GLUE - CLEAR GLUE 100OMT
1 BTL * 7.42 0.00 7.42 SR
LIOUID PAPER PAPERMATE NP10 7ML.
2 PCS X 3.71 0.00 7.42 SR
PERMAIET MARKCR SHARPE FNE BLAK 001
PCS X 2.33 0.00 2.33 SR
BALLPEN PILOT FRIXION 0.5 BLACK
1 PCS X 5.30 0.00 5.30 SR
SUB TOTA(INCLUSIVE GST) : 56.80
ROUNDING ADJUSTMENT : 0.01
ROUNDED TOTAL (RM): 56.80
CASH 100.00
CASH CHANGE 43.20
GST SUMMARY AMOUNT(RM) TAX(RM)
SR D 6 % 53.58 .21

Figure 11: Example text detection on complete receipt.

Summary

- Successfully implemented Text Detection and Text Recognition
- Dense Net and CRNN perform very similar on Text Recognition
- CRNN is faster then Dense Net
- CTC input size important for good predictions

Outlook

- Data augmentation for Text Detection $\rightarrow$ detect rotated bounding boxes
- Test different architectures of Dense Net and CRNN to improve prediction of long text further
- Improve image preprocessing $\rightarrow$ improve contrast
- General hyper parameter optimization

References

Edouard Belval. *TextRecognitionDataGenerator*. https://github.com/Belval/TextRecognitionDataGenerator. [Online; visited 23.07.2020]. 2019.

Dinh Sang and Le Cuong. “Improving CRNN with EfficientNet-like feature extractor and multi-head attention for text recognition”. In: Dec. 2019, pp. 285–290. ISBN: 978-1-4503-7245-9. DOI: 10.1145/3368926.3369689.

Harald Scheidl. *An Intuitive Explanation of Connectionist Temporal Classification.* https://towardsdatascience.com/intuitively-understanding-connectionist-temporal-classification-3797e43a86c. [Online; visited 20.07.2020]. 2018.

Ekin Tiu. *Metrics to Evaluate your Semantic Segmentation Model.* https://towardsdatascience.com/metrics-to-evaluate-your-semantic-segmentation-model-6bcb99639aa2. [Online; visited 20.07.2020]. 2019.

Sik-Ho Tsang. *Review: DenseNet — Dense Convolutional Network (Image Classification).* https://towardsdatascience.com/review-densenet-image-classification-b6631a8ef803. [Online; visited 20.07.2020]. 2018.

Xinyu Zhou et al. “EAST: An efficient and accurate scene text detector”. In: *Proceedings - 30th IEEE Conference on Computer Vision and Pattern Recognition, CVPR 2017*. Vol. 2017-Janua. 2017, pp. 2642–2651. ISBN: 9781538604571. DOI: 10.1109/CVPR.2017.283. arXiv: 1704.03155.

DenseNet

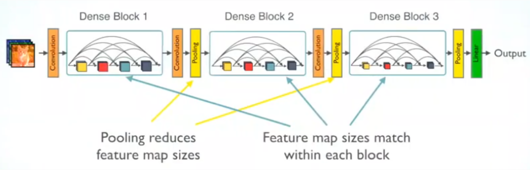


Figure 12: Basic structure of the DenseNet [5].

- Convolutional part build on dense blocks
- Like ResNet each layer receives additional data from all preceding layers, but using concatenation
- Down sample until height of each column is equal 1

Text Recognition Models - Loss

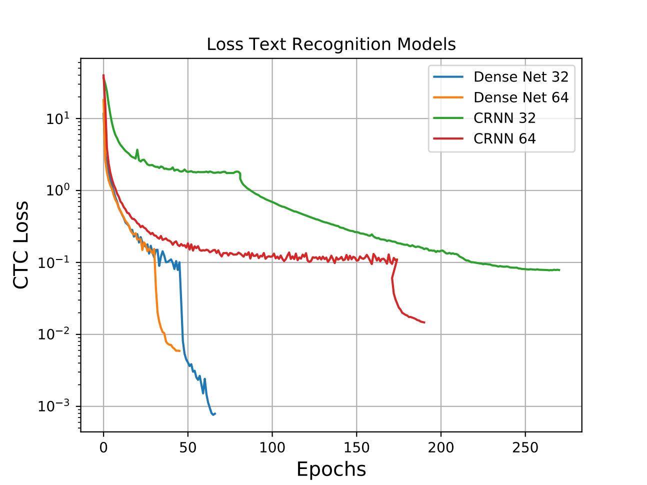
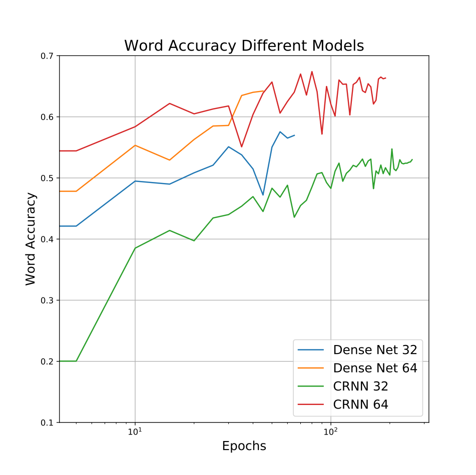
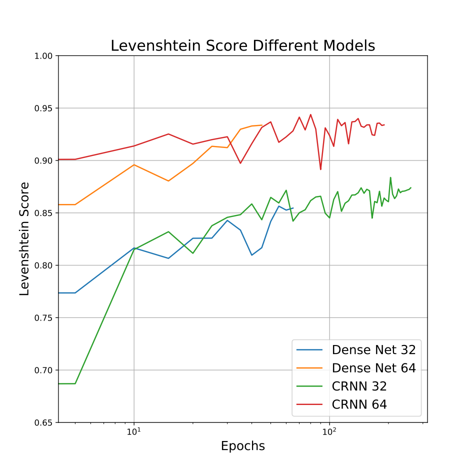


Figure 13: CTC loss for Text Recognition Models.

Results Text Recognition - Score





Results Text Recognition - Example Complete Receipt


0E
AEON CO. (M) BHD (126926-H)
3RD FLR, AEON TAMAN MALURI SC
JLN JEJAKA, TAMAN MALURI
CHERAS, 55100 KUALA LUMPUR
GST ID : 002017394688
SHOPPING HOURS
MON-SUN:1000 HRS - 2200 HRS
VALUED CUSTOMER: 1130307913

1x 000005469765 6.65SR
TOPVALU FLOOR C
1x 000001101575 5.60SR
CIF REGULAR 50

Sub-total 12.25
Total Sales Incl GST 12.25
Total After Adj Incl GST 12.25
CASH 50.00
Item Count 2 Change Amt 37.75
Invoice No: 2018031430090060035
GST Summary Amount Tax
SR @ 6% 11.55 0.70
Total 11.55 0.70
14/03/2018 12:43 3009 006 0060035
0284846 AMIRUL

True text	Predicted Text
AEON CO. (M) BHD (126926-H)	AEON CO. M) BHD (126926-H!
3RD FLR, AEON TAMAN MALURI SC	3RD FLR. AEON TAMAN MALURI SC
JLN JEJAKA, TAMAN MALURI	JLN JEJAKA. TAMAN MALURI
CHERAS, 55100 KUALA LUMPUR	CHERAS. 55100 KUALA LUMPUR
GST ID: 002017394688	GST D : 002017394688
SHOPPING HOURS	SHOPPING HOURS
MON-SUN: 1000 HRS - 2200 HRS	MON-SUN:1000 HRS - 2200 HRS
VALUED CUSTOMER: 1130307913	VAI UED CUSTOMER: 1130307913
1X 000005469765 6.65SR	1X 000005469765 6.65SR
TOPVALU FLOOR C	TOPVALU FIOOR C
1X 000001101575 5.60SR	1X 000001101575 5.60SR
CIF REGULAR 50	CIF REGULAR 50
SUB-TOTAL 12.25	SUB-TOTAL 12.25
TOTAL SALES INCL GST 12.25	TOTAL SALES INCL GST 12.25
TOTAL AFTER ADJ INCL GST 12.25	TOIAL AFTER ADI INCL GST 12.25
CASH 50.00	CASH 50.00
ITEM COUNT 2 CHANGE AMT 37.75	IFEM COUNT 2 CHAN9E AMT 37.75
INVOICE NO:2018031430090060035	INVOICE NO : 2018031430090060035
GST SUMMARY AMOUNT TAX	GST SUAMARY AMOUNT TAX
SR @ 6% 11.55 0.70	SR 6% 11.55 0.70
TOTAL 11.55 0.70	TOTAL 11.55 0.70
14/03/2018 12:43 3009 006 0060035	14/03/2018 12:43 3009 006 0060035
0284846 AMIRUL	0284846 AMIRUL

Figure 14: Example text detection on complete receipt.