



# Working at Eliiza + Automating data extraction from documents

NUMBAT seminar series

Anna Quaglieri  
21-04-2021

# About me



BSc & MSc in Statistics (Bologna, Glasgow, Melbourne)



1.5 years RA in Population Genetics (WEHI)

PhD in Cancer Genomics & Applied Statistics (WEHI)



Current Data Science consultant at **Eliiza**

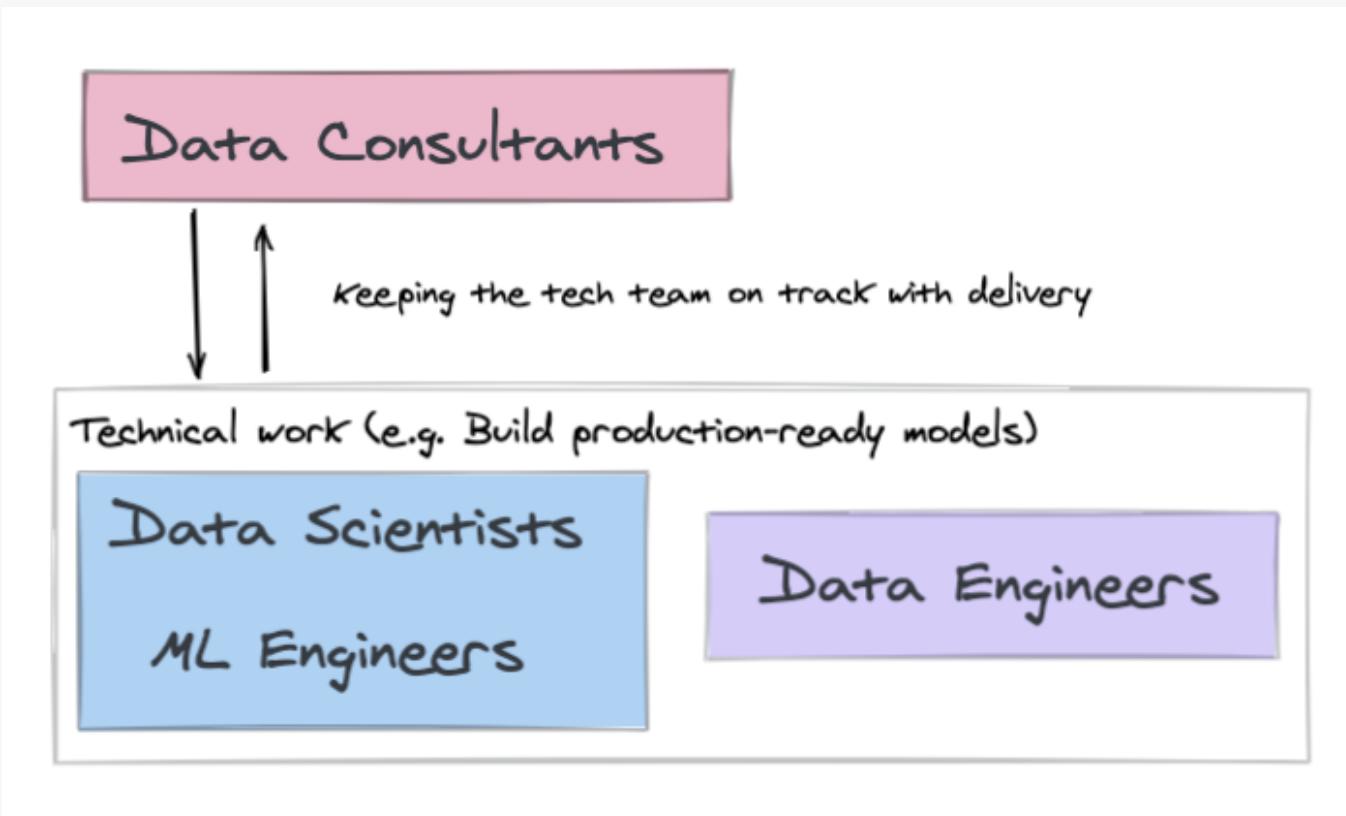


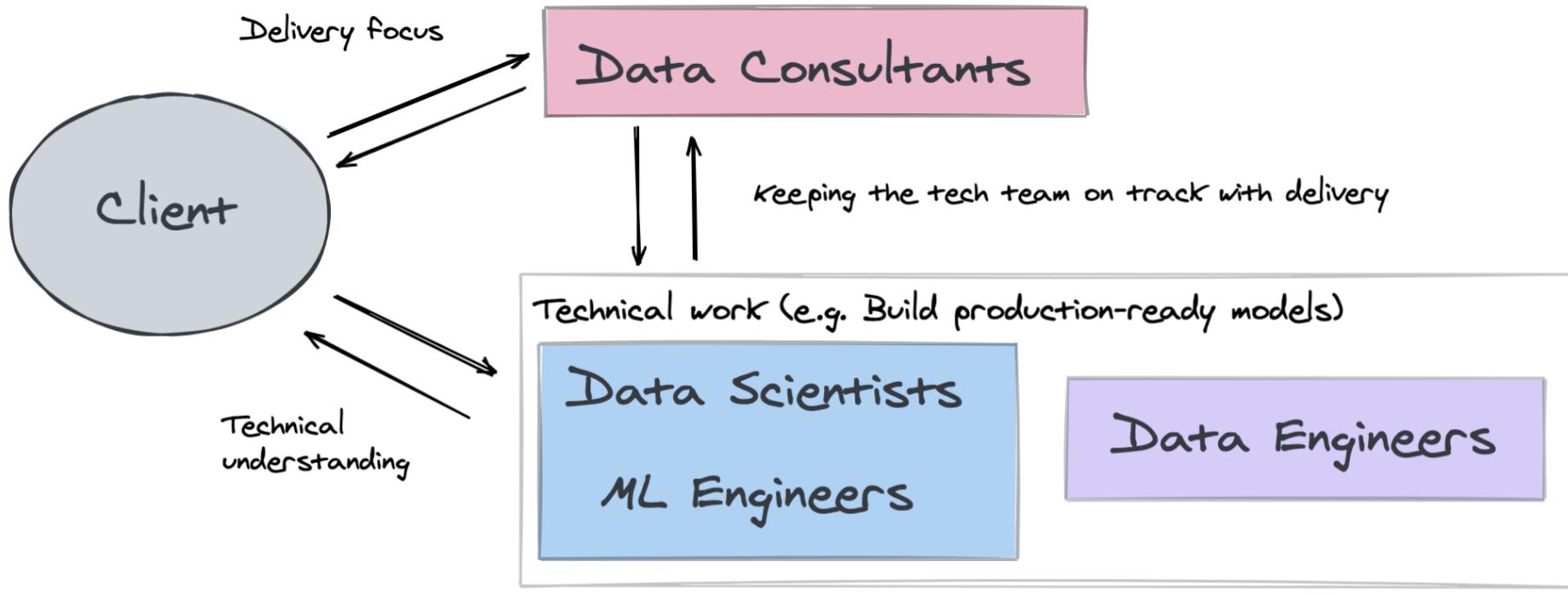
> 3 years organising R-Ladies Melbourne events



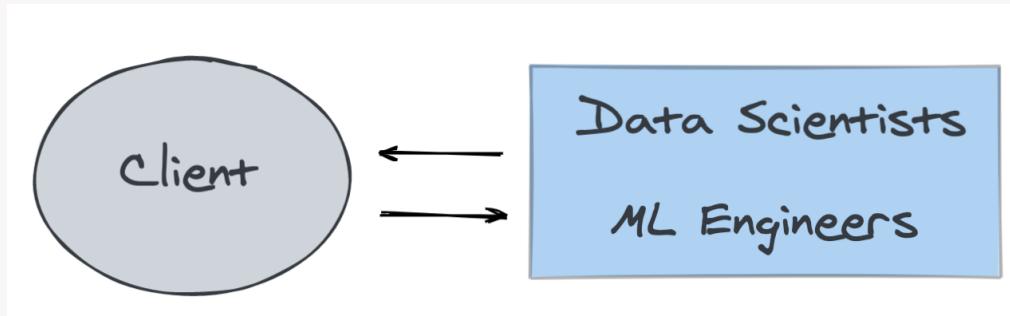
(Part of the)  
Eliiza Team



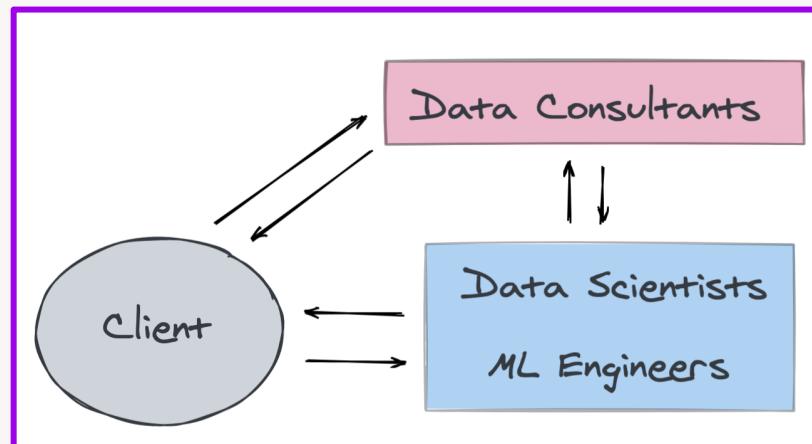
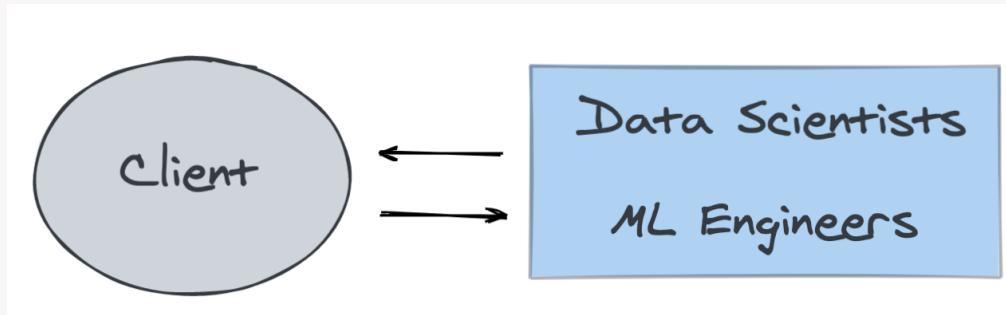




# My team work at Eliiza



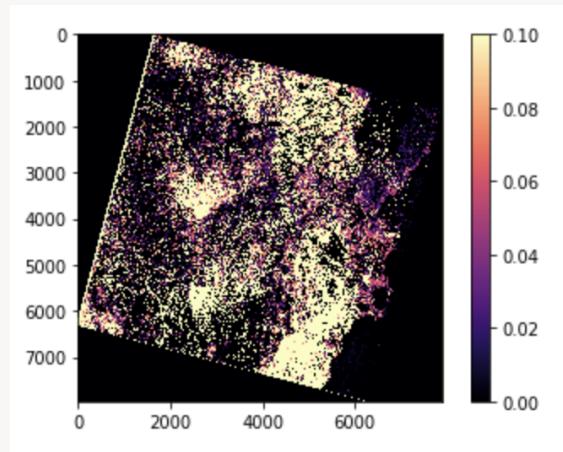
# My team work at Eliiza



For larger projects

# My work at Eliiza

- Detect **burnt areas** from **satellite images** using images before and after 2019 bushfires
  - Not much more than data collection due to COVID-19



# My work at Eliiza

- Detect **burnt areas** from **satellite images** using images before and after 2019 bushfires
- **Automate information extraction** from documents

# My work at Eliiza

- Detect **burnt areas** from **satellite images** using images before and after 2019 bushfires
- **Automate information extraction** from documents
- Production-ready predictive models

# **Automate information extraction from documents**

# Information extraction from documents

Extract data from documents for downstream tasks

Data/information in this talk is **text** not images

# Why automate information extraction?

- Reduce burden of repetitive manual tasks
- Push towards digital information vs paper documents
- Increase efficiency and speed in repetitive but necessary tasks
- Standardize extraction and output to reduce risk of human error Automation error will still be present (systematic or probabilistic)

# Processing pharmacy receipts for insurance claims



Item	Charge
Baby lotion	25.98
Vicks Vapo Rub	7.49
etc..	etc..

## Detect and extract information from personal documents

- Report cybersecurity breaches
- Proof of identity



# Common tasks

1. **Classify** a document into one of k categories (payslips, passport, bank statement)
1. **Extract key information** from the document

# I will discuss

1. Common Optical Character Recognition (OCR) engines
2. Extract targeted information with heuristics
3. Beyond heuristics

# **1. Common Optical Character Recognition (OCR) engines**

# Common OCR engines

- Amazon Textract (\$)  
[boto3](#)
- Google Cloud: Document AI Services (\$)  
[Google Cloud console](#)  
[google-cloud-documentai](#)
- Tesseract (free and open source)  
[tesseract](#)  
[pytesseract](#)

# Common OCR engines

- Amazon Textract (\$)
  - Run from Amazon Web Services (AWS) console
  - Python: [\*\*boto3\*\*](#) (Client Class)
- Google Cloud: Document AI Services (\$)  
[Google Cloud console](#)  
[google-cloud-documentai](#)
- Tesseract (free and open source)  
[tesseract](#)  
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# Common OCR engines

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  - Run from [Google Cloud console](#) (Free to try on small documents!)
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  - [tesseract](#)
  - [pytesseract](#)

# Common OCR engines

- Amazon Textract (\$)
  - Run from Amazon Web Services (AWS) console
  - Python: [\*\*boto3\*\*](#) (Client Class)
- Google Cloud: Document AI Services (\$)
  - Run from [\*\*Google Cloud console\*\*](#) (Free to try on small documents!)
  - Python: [\*\*google-cloud-documentai\*\*](#)
- Tesseract (free and open source)
  - Command line: [\*\*tesseract\*\*](#)
  - Python: [\*\*pytesseract\*\*](#)

## Other common available engines

- [Blog post](#) comparing these and other OCR tools (ABBYY FineReader)
- [Azure OCR services](#)

## **2. Extract targeted information with heuristics**

# Input Document

PAYSLIP FOR	PAID BY	EMPLOYMENT DETAILS	
Jack Black	Joey's Diner Pty Ltd	Pay Frequency:	Fortnightly
1 Jet Street	Mark St	Employment Basis:	Casual
Blackville TAS 3333	BAYSWATER VIC 3153	employment	
Classification: Waste of space	ABN 84 111 122 223		
			
Pay Period: 02/12/2013 - 15/12/2013	Payment Date: 18/12/2013	Total Earnings: \$2,000.00	Net Pay: \$1,200.00
		THIS PAY	YTD
SALARY & WAGES		RATE	
Commission	1.0000 Hours	\$2,000.0000	\$2,000.00
Other Previous Earnings			\$11,500.00
	TOTAL	\$2,000.00	\$13,500.00
TAX			
PAY Tax		\$930.00	\$6,278.00
Manual Adjustment		(\$130.00)	(\$130.00)
	TOTAL	\$800.00	\$6,148.00
SUPERANNUATION			
SGC - Spectrum (old) use: Spectrum Super (IOOF Portfolio Service Super Fund) - 8899		\$185.00	\$1,248.75
	TOTAL	\$185.00	\$1,248.75
LEAVE	ACCRUED	USED	BALANCE
Annual Leave in Hours	0.00	0.00	5.77
PAYMENT DETAILS	REFERENCE	AMOUNT	
(063-123)***712	Jack Black	\$1,200.00	

# OCR output



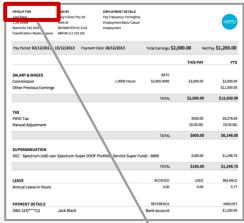
Textract

 apiResponse.json
 keyValues.csv
 rawText.txt
 table-1.csv
 table-2.csv

# apiResponse.json: text + location on the page

PAYSLIP FOR	PAID BY	EMPLOYMENT DETAILS
Jack Black	Joey's Diner Pty Ltd	Pay Frequency: Fortnightly
1 Jet Street	Mark St	Employment Basis: Casual
Blackville TAS 3333	BAYSWATER VIC 3153	employment
Classification: Waste of space	ABN 84 111 122 223	
Pay Period: 02/12/2013 - 15/12/2013	Payment Date: 18/12/2013	Total Earnings: \$2,000.00 Net Pay: \$1,200.00
THIS PAY		YTD
<b>SALARY &amp; WAGES</b>		
Commission	1.0000 Hours	RATE \$2,000.0000
Other Previous Earnings		\$2,000.00 \$11,500.00
	TOTAL	\$2,000.00 \$13,500.00
TAX		
PAYG Tax		\$930.00 \$6,278.00
Manual Adjustment		(\$130.00) (\$130.00)
	TOTAL	\$800.00 \$6,148.00
<b>SUPERANNUATION</b>		
SGC - Spectrum (old) use: Spectrum Super (IOOF Portfolio Service Super Fund) - 8899		\$185.00 \$1,248.75
	TOTAL	\$185.00 \$1,248.75
LEAVE		
Annual Leave in Hours	ACCRUED 0.00	USED 0.00
	BALANCE 5.77	
PAYMENT DETAILS		
(063-123)***712	Jack Black	REFERENCE Bank account
		AMOUNT \$1,200.00

PAYSLIP FOR	PAID BY	EMPLOYMENT DETAILS
Jack Black	Joey's Diner Pty Ltd	Pay Frequency: Fortnightly
1 Jet Street	Mark St	Employment Basis: Casual
Blackville TAS 3333	BAYSWATER VIC 3153	employment
Classification: Waste of space	ABN 84 111 122 223	
Pay Period: 02/12/2013 - 15/12/2013	Payment Date: 18/12/2013	Total Earnings: \$2,000.00 Net Pay: \$1,200.00
THIS PAY		YTD
<b>SALARY &amp; WAGES</b>		
Commission	1.0000 Hours	RATE \$2,000.0000
Other Previous Earnings		\$2,000.00 \$11,500.00
	TOTAL	\$2,000.00 \$13,500.00
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	TOTAL	\$185.00 \$1,248.75
LEAVE		
Annual Leave in Hours	ACCRUED 0.00	USED 0.00
	BALANCE 5.77	
PAYMENT DETAILS		
(063-123)***712	Jack Black	REFERENCE Bank account
		AMOUNT \$1,200.00

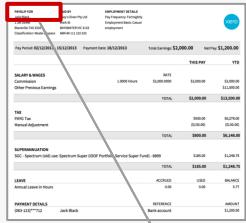


PAYSHEET FOR  
Jack Black  
1 Jet Street  
Blackville TAS 3333  
Classification: Waste of space

## apiResponse.json

```
{  
    "BlockType": "LINE",  
    "Confidence": 97.95972442626953,  
    "Text": "PAYSHEET FOR",  
    "Geometry": {  
        "BoundingBox": {  
            "Width": 0.07683917135000229,  
            "Height": 0.013413328677415848,  
            "Left": 0.03804675117135048,  
            "Top": 0.05010952427983284  
        },  
        "Polygon": [  
            {  
                "X": 0.03804675117135048,  
                "Y": 0.05010952427983284  
            },  
            {  
                "X": 0.11488592624664307,  
                "Y": 0.05010952427983284  
            },  
            {  
                "X": 0.11488592624664307,  
                "Y": 0.06352285295724869  
            },  
            {  
                "X": 0.03804675117135048,  
                "Y": 0.06352285295724869  
            }  
        ]  
    },  
    "Id": "db8fd474-4d63-4f4f-8609-76bf047d5ac7",  
    "Relationships": [  
        {  
            "Type": "CHILD",  
            "Ids": [  
                "911300e6-8489-4b92-9c43-1c77170e30e7",  
                "b11b45cc-08ec-4e80-a9a8-3f560b312299"  
            ]  
        }  
    ]  
},
```

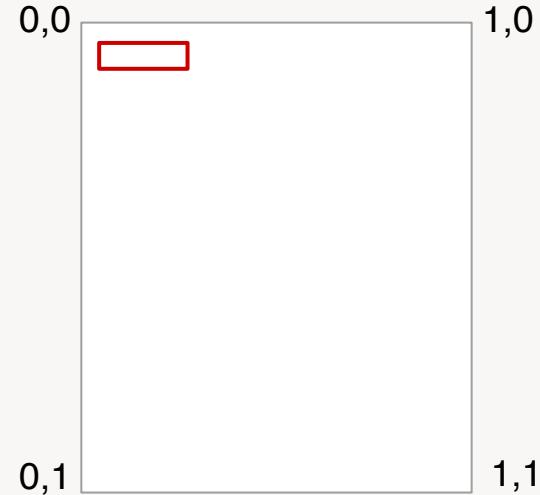
## Text and confidence

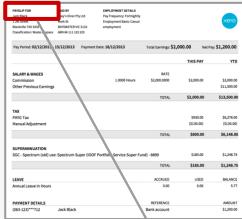


apiResponse.json

```
{  
    "BlockType": "LINE",  
    "Confidence": 97.95972442626953,  
    "Text": "PAYSPLIT FOR",  
    "Geometry": {  
        "BoundingBox": {  
            "Width": 0.07683917135000229,  
            "Height": 0.013413328677415848,  
            "Left": 0.03804675117135048,  
            "Top": 0.05010952427983284  
        },  
        "Polygon": [  
            {  
                "X": 0.03804675117135048,  
                "Y": 0.05010952427983284  
            },  
            {  
                "X": 0.11488592624664307,  
                "Y": 0.05010952427983284  
            },  
            {  
                "X": 0.11488592624664307,  
                "Y": 0.06352285295724869  
            },  
            {  
                "X": 0.03804675117135048,  
                "Y": 0.06352285295724869  
            }  
        ]  
    },  
    "Id": "db8fd474-4d63-4f4f-8609-76bf047d5ac7",  
    "Relationships": [  
        {  
            "Type": "CHILD",  
            "Ids": [  
                "911300e6-8489-4b92-9c43-1c77170e30e7",  
                "b11b45cc-08ec-4e80-a9a8-3f560b312299"  
            ]  
        }  
    ],  
    "TextRun": "PAYSPLIT FOR",  
    "TextRunX": 0.05, "TextRunY": 0.05, "TextRunW": 0.07683917135000229, "TextRunH": 0.013413328677415848  
}
```

Scaled location on the page





PAYSLIP FOR  
Jack Black  
1 Jet Street  
Blackville TAS 3333  
Classification: Waste of space

## apiResponse.json

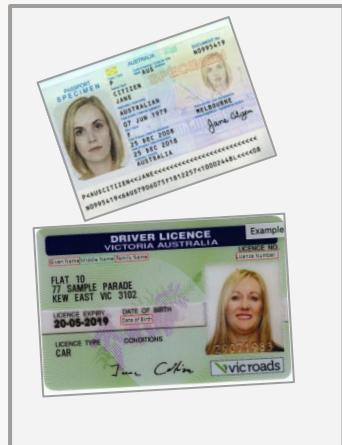
```
{  
    "BlockType": "LINE",  
    "Confidence": 97.95972442626953,  
    "Text": "PAYSLIP FOR",  
    "Geometry": {  
        "BoundingBox": {  
            "Width": 0.07683917135000229,  
            "Height": 0.013413328677415848,  
            "Left": 0.03804675117135048,  
            "Top": 0.05010952427983284  
        },  
        "Polygon": [  
            {  
                "X": 0.03804675117135048,  
                "Y": 0.05010952427983284  
            },  
            {  
                "X": 0.11488592624664307,  
                "Y": 0.05010952427983284  
            },  
            {  
                "X": 0.11488592624664307,  
                "Y": 0.06352285295724869  
            },  
            {  
                "X": 0.03804675117135048,  
                "Y": 0.06352285295724869  
            }  
        ]  
    },  
    "Id": "db8fd474-4d63-4f4f-8609-76bf047d5ac7",  
    "Relationships": [  
        {  
            "Type": "CHILD",  
            "Ids": [  
                "911300e6-8489-4b92-9c43-1c77170e30e7",  
                "b11b45cc-08ec-4e80-a9a8-3f560b312299"  
            ]  
        }  
    ]  
},
```

## Hierarchical structure with words

# Strategies using only text - Classify document category

Build Natural Language Processing (NLP) models to detect presence of particular document types:

E.g. Train model on passports, driver licences, bank details keywords



OCR



NLP models  
spaCy  
flair

Document flagged
Passport
Driver licence

# Information extraction

## Strategies using text + spatial location on page



pii_flagged	page	name	dob	passport_number
passport	1	CITIZEN JANE	07 JUN 1984	PA0940443

# Strategies using text + spatial location on page

Heuristics (rule based approach)

geopandas

pandas

shapely

# Strategies using text + spatial location on page

Heuristics (rule based approach)

Leverage Python packages to work with:

- **Text**
  - [fuzzywuzzy](#): string matching (search for specific fields/keywords)
  - [re](#): regular expression operations

[geopandas](#)

[pandas](#)

[shapely](#)

# Strategies using text + spatial location on page

Heuristics (rule based approach)

Leverage Python packages to work with:

- **Text**
  - [fuzzywuzzy](#): string matching (search for specific fields/keywords)
  - [re](#): regular expression operations
- **Spatial data**
  - [geopandas](#): extends [pandas](#) data types to allow geometric manipulation in a dataframe structure
  - [shapely](#): introduces manipulation of geometric objects used by geopandas

## Application: key-value pairs

PAYROLL INFORMATION		EMPLOYMENT DETAILS	
Pay Period		Pay Frequency	
Employee Name		Employment Basis	
Address		Hiring Date	
Classification/Type of Employee		Last Modified	
Pay Period: 02/12/2013 - 03/12/2013		Payment Date: 03/12/2013	
		Total Earnings: \$2,000.00	
		Net Pay: \$1,200.00	
		THIS PAY	
		YTD	
<b>SALARY &amp; WAGES</b>			
Commission		1,000 Hours	
		\$2,000.0000	
Other Previous Earnings		\$2,000.0000	
		\$11,300.00	
		<b>TOTAL:</b>	
		<b>\$2,000.00</b>	
		<b>\$13,500.00</b>	
<b>TAX</b>			
PRTC Tax		\$90.00	
Manual Adjustment		(\$130.00)	
		\$(-40.00)	
		<b>TOTAL:</b>	
		<b>\$800.00</b>	
<b>SUPERANNUATION</b>			
SSC - Spectrum (Add) over Spectrum Super (ODCF Portfolio Service Super Fund):		\$899	
		\$385.00	
		<b>TOTAL:</b>	
		<b>\$899.00</b>	
<b>LEAVE</b>			
Annual Leave in Hours		ACCUSED	
		0.00	
		BALANCE	
		0.00	
		5.77	
<b>PAYOUT DETAILS</b>			
(OK3 1234567712)		REFERENCE	
Jack Black		Bank account	
		\$1,200.00	



# Application: key-value pairs

PAYSLIP FOR	PAID BY	EMPLOYMENT DETAILS
Jack Black	Jack Black Pty Ltd	Payroll System Manager
1 Jet Street	Mark St	Employment Basis: Contract
Blackville TAS 3333	Bankwest VIC 2333	Employment Start Date:
Classification: Waste of space	ABN 12 123 232 232	employment

Pay Period: 02/12/2013 - 15/12/2013 Payment Date: 18/12/2013 Total Earnings: \$2,000.00 Net Pay: \$1,200.00

	THIS PAY	YTD	
SALARY & WAGES			
Commission	\$2,000.00	\$2,000.00	
Other Previous Earnings	\$1,200.00	\$1,200.00	
<b>TOTAL</b>	<b>\$2,000.00</b>	<b>\$3,200.00</b>	
TAX			
FNSC Tax	\$80.00	\$1,279.40	
Manual Adjustment	(\$10.00)	(\$10.00)	
<b>TOTAL</b>	<b>\$800.00</b>	<b>\$4,148.40</b>	
SUPERANNUATION			
SOC: Spectrum (id: user: Spectrum Super (IOOF Portfolio Service Super Fund): 8889	\$80.00	\$1,248.75	
<b>TOTAL</b>	<b>\$80.00</b>	<b>\$1,248.75</b>	
LEAVE	ACCRUED	USED	BALANCE
Annual Leave in Hours	0.00	0.00	0.77
PAYOUT DETAILS	REFERENCE	AMOUNT	
(061 123****)112	Jack Black	Bank account	\$1,200.00

OCR

PAYSLIP FOR	PAID BY	EMPLOYMENT DETAILS
Jack Black	Jack Black Pty Ltd	Payroll System Manager
1 Jet Street	Mark St	Employment Basis: Contract
Blackville TAS 3333	Bankwest VIC 2333	Employment Start Date:
Classification: Waste of space	ABN 12 123 232 232	employment

Pay Period: 02/12/2013 - 15/12/2013 Payment Date: 18/12/2013 Total Earnings: \$2,000.00 Net Pay: \$1,200.00

	THIS PAY	YTD	
SALARY & WAGES			
Commission	\$2,000.00	\$2,000.00	
Other Previous Earnings	\$1,200.00	\$1,200.00	
<b>TOTAL</b>	<b>\$2,000.00</b>	<b>\$3,200.00</b>	
TAX			
FNSC Tax	\$80.00	\$1,279.40	
Manual Adjustment	(\$10.00)	(\$10.00)	
<b>TOTAL</b>	<b>\$800.00</b>	<b>\$4,148.40</b>	
SUPERANNUATION			
SOC: Spectrum (id: user: Spectrum Super (IOOF Portfolio Service Super Fund): 8889	\$80.00	\$1,248.75	
<b>TOTAL</b>	<b>\$80.00</b>	<b>\$1,248.75</b>	
LEAVE	ACCRUED	USED	BALANCE
Annual Leave in Hours	0.00	0.00	0.77
PAYOUT DETAILS	REFERENCE	AMOUNT	
(061 123****)112	Jack Black	Bank account	\$1,200.00



**PAYSLIP FOR**

Jack Black  
1 Jet Street  
Blackville TAS 3333  
Classification: Waste of space

- Find text blocks containing the keyword: “payslip”

# Application: key-value pairs

PAYSLIP FOR	PAID BY	EMPLOYMENT DETAILS	
Jack Black	John Doe Pay Ltd	Pay Period: 01/12/2013 - 15/12/2013	
Address:	Mark St	Employment Type: Full-time	
City:	Blackville TAS 3333	Employment Basis: Contract	
Classification:	Waste of space	Employer Name: XYZ Corp	
ABN:	123 123 123	ABN:	
Confirmation Number of space:		Bank Account:	
		\$1,200.00	
Pay Period: 01/12/2013 - 15/12/2013 Payment Date: 18/12/2013 Total Earnings: \$2,000.00 Net Pay: \$1,200.00			
THIS PAY YTD			
SALARY & WAGES	RATE		
Commission	1,200.00 Hours	\$2,000.00	
Other Previous Earnings		\$1,200.00	
	TOTAL	\$2,000.00	
		\$1,200.00	
TAX			
FNSC Tax		\$120.00	
Manual Adjustment		(\$10.00)	
	TOTAL	\$800.00	
		\$4,148.00	
SUPERANNUATION			
SOC: Spectrum (id: 6) user: Spectrum Super (ISOF Portfolio Service Super Fund): 8889		\$100.00	
	TOTAL	\$100.00	
		\$1,248.75	
LEAVE	ACCRED	USED	BALANCE
Annual Leave in Hours	0.00	0.00	5.77
PAYOUT DETAILS	REFERENCE	AMOUNT	
(061 123****112)	Jack Black	Bank account	\$1,200.00

OCR

PAYSLIP FOR	PAID BY	EMPLOYMENT DETAILS	
Jack Black	John Doe Pay Ltd	Pay Period: 01/12/2013 - 15/12/2013	
Address:	Mark St	Employment Type: Full-time	
City:	Blackville TAS 3333	Employment Basis: Contract	
Classification:	Waste of space	Employer Name: XYZ Corp	
ABN:	123 123 123	ABN:	
Confirmation Number of space:		Bank Account:	
		\$1,200.00	
Pay Period: 01/12/2013 - 15/12/2013 Payment Date: 18/12/2013 Total Earnings: \$2,000.00 Net Pay: \$1,200.00			
THIS PAY YTD			
SALARY & WAGES	RATE		
Commission	1,200.00 Hours	\$2,000.00	
Other Previous Earnings		\$1,200.00	
	TOTAL	\$2,000.00	
		\$1,200.00	
TAX			
FNSC Tax		\$120.00	
Manual Adjustment		(\$10.00)	
	TOTAL	\$800.00	
		\$4,148.00	
SUPERANNUATION			
SOC: Spectrum (id: 6) user: Spectrum Super (ISOF Portfolio Service Super Fund): 8889		\$100.00	
	TOTAL	\$100.00	
		\$1,248.75	
LEAVE	ACCRED	USED	BALANCE
Annual Leave in Hours	0.00	0.00	5.77
PAYOUT DETAILS	REFERENCE	AMOUNT	
(061 123****112)	Jack Black	Bank account	\$1,200.00



PAYSLIP FOR  
Jack Black  
1 Jet Street  
Blackville TAS 3333  
Classification: Waste of space

Key	Value
Payslip for	Jack Black

- Find text blocks containing the keyword: “payslip”
- Detect the block spatially closest to it and below it

# Extraction from a template - Passport

**Combine semantics and spatial searches to extract fields from a known template**



```
page = read_file("passport.png",
                  engine = "textract")
extract_passport_details(page)
```

pii_flagged	page	name	dob	passport_number
passport	1	CITIZEN JANE	07 JUN 1984	PA0940443

# Limitations of heuristics

While we delivered a successful story <https://www.itnews.com.au/news/nib-adopts-machine-learning-for-claims-processing-555752>

But:

- Hard to scale when a large number of template is available
- Requires a lot of manual work which can be substituted by a model

### **3. Beyond heuristics (Under current experimentation)**

# **Machine Learning approaches to perform information extraction**

Common approach to combine **Computer Vision (CV)** approaches with **Natural Language Processing (NLP)** methods

## **Robust Reading Competitions**

<https://rrc.cvc.uab.es/?ch=13&com=evaluation&task=1>

# **Review of some published methods**

- Code available
- Combine text with geometric layout in the same model

**CUTIE** (<https://arxiv.org/pdf/1903.12363v4.pdf>)

Based on Convolutional Neural Network (CNN)

**LayoutLM** (<https://arxiv.org/pdf/1912.13318.pdf>)

Extension of BERT natural language processing model

**LAMBERT** (<https://arxiv.org/pdf/2002.08087.pdf>)

Extension of RoBERTa (extension of BERT) including layout embeddings

# CUTIE = Convolutional Universal Text Information Extractor

Based on **CNN** - traditionally used to build computer vision models

**Input data:** text mapped on a standardised grid

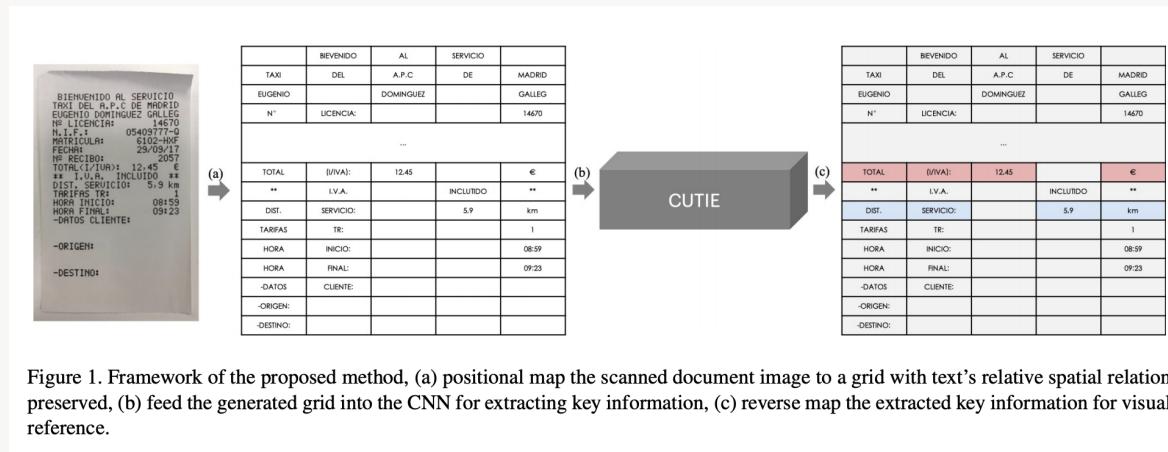
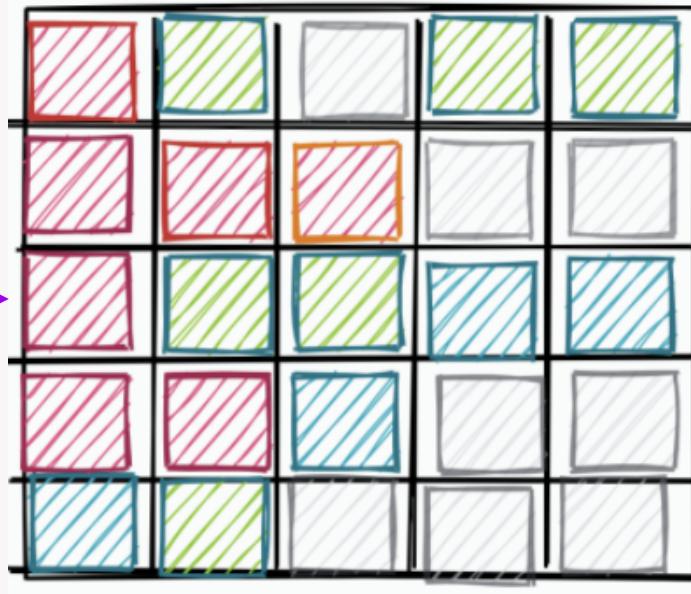


Figure 1. Framework of the proposed method, (a) positional map the scanned document image to a grid with text's relative spatial relation preserved, (b) feed the generated grid into the CNN for extracting key information, (c) reverse map the extracted key information for visual reference.

# The NLP part of CUTIE

From text to numbers

	BIEVENIDO	AL	SERVICIO	
TAXI	DEL	A.P.C	DE	MADRID
EUGENIO		DOMINGUEZ		GALLEG
Nº	LICENCIA:			14670
TOTAL	[[I/V/A]:	12.45		€
**	I.V.A.		INCLUIDO	**
DIST.	SERVICIO:		5.9	km
TARIFAS	TR:			1
HORA	INICIO:			08:59
HORA	FINAL:			09:23
-DATOS	CLIENTE:			
-ORIGEN:				
-DESTINO:				



# The NLP part of CUTIE

## From text to numbers

### 1. Tokenization

```
[the cat is playing']
```

```
['the', 'cat', 'is',  
 'play', '#ing']
```

#### Huggingface

[https://huggingface.co/transformers/  
tokenizer\\_summary.html](https://huggingface.co/transformers/tokenizer_summary.html)

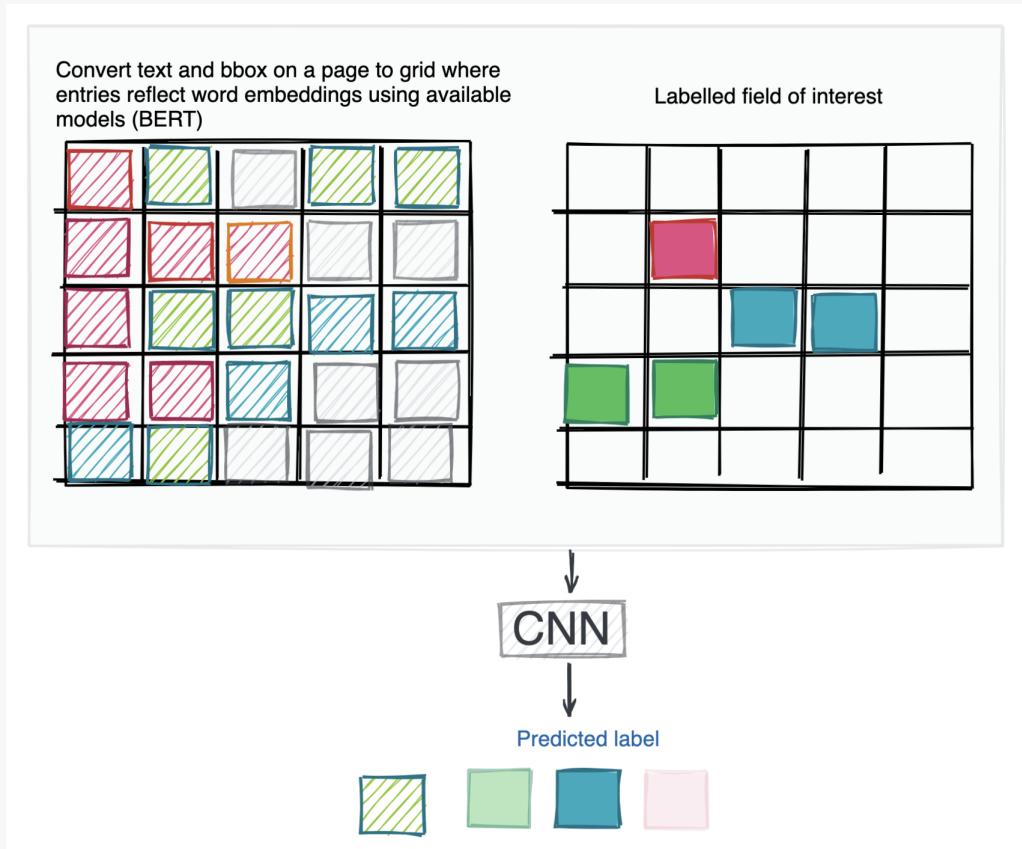
### 2. Embeddings

Convert tokens to real-valued vectors

Words with same meaning  
(and context) are closer

[Practical blog post on  
BERT word embeddings](#)

# The CV part of CUTIE



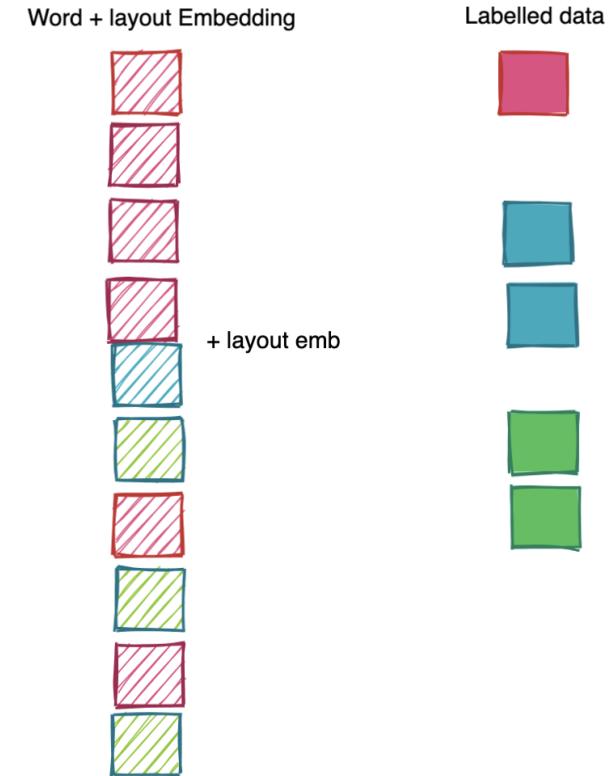
# BERT based models

## LayoutLM

 Available in the Huggingface ecosystem

## LAMBERT

No code implementation yet



# What next?

- Question?
- [Other Eliiza Brown Bags](#)

[Graph Theory in Data Science](#) with Ana Mamatelashvili

Includes applications of graph theory to text processing

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