# Kleister: A novel task for Information Extraction involving Long Documents with Complex Layout

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#### **Abstract**

State-of-the-art solutions for Natural Language Processing (NLP) are able to capture a broad range of contexts, like the sentence-level context or document-level context for short documents. But these solutions are still struggling when it comes to longer, real-world documents with the information encoded in the spatial structure of the document, such as page elements like tables, forms, headers, openings or footers; complex page layout or presence of multiple pages.

To encourage progress on deeper and more complex Information Extraction (IE) we introduce a new task (named *Kleister*) with two new datasets. Utilizing both textual and structural layout features, an NLP system must find the most important information, about various types of entities, in long formal documents. We propose *Pipeline* method as a text-only baseline with different Named Entity Recognition architectures (Flair, BERT, RoBERTa). Moreover, we checked the most popular PDF processing tools for text extraction (pdf2djvu, Tesseract and Textract) in order to analyze behavior of IE system in presence of errors introduced by these tools.

### 1 Introduction

Information Extraction (IE) requires quick but careful skimming through the whole document. We often have to not only search for pieces of information, but also to generate final output for specific entity type (e.g. aggregate multiple occurrences of organization names into one). In practice, this means that the results should be presented in an appropriate form (e.g. data points such as addresses normalized to a standard form). It should also be explained why certain information has been correlated. This may take the form of an indication in the input text. The process can be tedious and difficult for humans to do. Thus, we need automated systems to cope with multiple documents and to extract the required information in a simple and efficient way.

However, the disparity between what can be done with the state of the art in IE and what is required by real-world business use cases is still large. From the point of view of business users, systems that automatically gather information about individuals, their roles, significant dates, addresses, and amounts from invoices, companies reports and contracts, would be useful (Holt and Chisholm, 2018; Katti et al., 2018; Wróblewska et al., 2018; Sunder et al., 2019). Furthermore, the systems should be reliable and should reliably assess their own certainty about extracted entities.

However, as far as the state of the art is concerned, there are many machine learning models which must be trained for general named entities to be robust (Peters et al., 2018; Akbik et al., 2018; Devlin et al., 2018). To further increase training efficiency, we can use the documents of a previously defined layout, so that the models could learn how to extract a particular piece of information (Zhao et al., 2019; Denk and Reisswig, 2019; Liu et al., 2019a; Sarkhel and Nandi, 2019). On the other hand, more general extractors are still needed to deal with a variety of information.

In this paper, we describe two novel datasets for Information Extraction from long documents with complex layouts. We will begin by explaining the need for the dataset that would contain authentic scenarios to provide a review of similar tasks and datasets in the next step (Section 2). Then, we describe

characteristics of datasets in details (Section 3). Subsequently, we describe baseline methods (using only textual information, without relying directly on 2D information) and their results (with different PDF processing tools) applied to cope with the task with the *Pipeline* approach described in Section 4. Finally, we discuss challenges in the process to extract the proper entities (Section 5).



Figure 1: Three different examples of layouts from the Kleister-charity dataset.

### 2 Review of Information Extraction Datasets

Our main idea for preparing a new dataset was to develop a strategy to deal with the main challenge we face in business conditions, which means overcoming such difficulties as: complex layout, specific business logic (the way the content is formulated), OCR quality, document-level extraction and normalization.

The most similar dataset to our approach regarding the NLP field is the WikiReading dataset and related challenges (Hewlett et al., 2016). This dataset is a large-scale natural language understanding task with 18 million entities and 4.7 million documents. The goal of the task is to predict textual values from the structured knowledge base, Wikidata, by reading the text of the corresponding Wikipedia articles. Some entities can be extracted from the given text, but some of them have to be inferred. Thus, similarly as in our assumptions, the task contains a rich variety of challenging extraction sub-tasks and is also well-suited for end-to-end models. In both sets there are also challenges with output data normalization, e.g. dates, names.

However, our datasets are even more difficult to process, because they comprise documents with complex layout, noisy OCR-ed input (made by an Optical Character Recognition system) and they are much longer than an average Wikipedia article. These are the main issues that distinguish it from WikiReading and which justify why our task is not only about understanding the language.

A list of challenges similar to some degree to our goal is also available at the International Conference on Document Analysis and Recognition ICDAR 2019<sup>1</sup>. However, the authors focus mainly on understanding tables and a limited range of document layouts, not extracting particular information from the data. There is a dataset called Form Understanding in Noisy Scanned Documents (FUNSD) (Guillaume Jaume, 2019). FUNSD aims at extracting and structuring the textual content of forms. Unfortunately, the dataset comprises only 200 scanned and annotated forms and the annotations are too general, i.e. question, answer, header.

http://icdar2019.org/competitions-2/

Another interesting dataset from ICDAR 2019 is a set of scanned receipts. The authors prepared 1000 whole scanned receipt images with annotations of company name, date, address and the total payment amount<sup>2</sup>. Of course, receipts are short documents, and have quite a uniform layout and information structure (they start with the company name, date and invoice number etc.).

Finally, there are datasets with the information extraction task based on invoices, which are not publicly available to the community (Holt and Chisholm, 2018; Katti et al., 2018). Documents of this kind contain common entities like 'Invoice date', 'Invoice number', 'Net amount' and 'Vendor Name' which are extracted using a combination of Natural Language Processing and Computer Vision techniques. This is because spatial information is important to properly understand such documents. However, since they are usually short, there is rather no repetition of the same information, so there is no need to understand the context.

#### 3 Kleister: New Datasets

The main goal of the gathered datasets introduced in this paper is to emphasize business value and focus more on problems related to layout analysis and Information Extraction, as well as Natural Language Understanding (several entities should be inferred from the whole document context). Thus, it can be performed as well as an end-to-end task that can be used in real life use cases for robotic process automation of information extraction from documents of complex layout.

We collected datasets of long formal documents that are US non-disclosure agreements (*Kleister-NDA*) and annual financial reports of charitable foundations in the UK (*Kleister-Charity*). The datasets (training and development sets as well as the input to the main test set)<sup>3</sup> are available at https://github.com/applicaai/kleister-nda and https://github.com/applicaai/kleister-charity.

Kleister datasets have a multi-modal input (i.e. text versions were obtained from OCR-ed noisy documents, some of which contain illustrations and some were scans) and a list of entities to be found. The list of reference findings is not indicated in the input documents. This is not a NER task, in which we would be interested in determining where a given piece of information or entity is in the text. We are interested in the information itself. Moreover, we assume that in our datasets some documents may be missing some entities, or some entities may have more than one gold value. The input of the dataset comprises: PDF files and text versions of the documents (we used most popular tools for extraction text from PDF files).

These two datasets have been gathered in different ways because of their repository structures. Also, the reasons why they were published on the Internet were different. The most important difference between them is that the NDA dataset was born-digital but the Charity dataset needed to be OCR-ed. The detailed information about aforementioned open datasets (which are the most popular ones in the domain) and our *Kleister* datasets are presented in Table 1.

#### 3.1 NDA Dataset

The NDA Dataset contains Non-disclosure Agreements, also known as Confidential Agreements. They are legally binding contracts between two or more parties, through which the parties agree not to disclose information covered by the agreement. The NDAs were collected from the Electronic Data Gathering, Analysis and Retrieval system (EDGAR) via Google search engine. Then, a list of entities was established (see Table 2) and documents were manually annotated by a team of linguists, which ensured excellent quality of the annotation ( $\kappa = 0.971^4$ ).

In Figure 2, there is an example of a problematic entity in a Non-Disclosure Agreement: effective date. It is the date on which the contract enters into force. In general, it coincides with the date of the contract or the date it was signed. It happens, however, that these dates are different and then the date

<sup>2</sup>https://rrc.cvc.uab.es/?ch=13

<sup>&</sup>lt;sup>3</sup>We are planning to set up a shared-task platform where submissions could be evaluated for the test set as well.

<sup>&</sup>lt;sup>4</sup>This is the average result for all entities — Cohen's kappa coefficient was calculated for each entities on the basis of double annotation of 100 random documents from the entire NDA Dataset. A detailed description of the data collection method and annotation procedure can be found in the Appendix.

of entry into force of the contract is specially marked, e.g. as 'Effective date'. However, none of dates in the figure is specified in this way. Most NDAs contain a special clause that indicates the date of entry into force of the contract. Usually it is immediately before the signatures of the parties. In this case, the correct answer is November 20, 2008, because in this agreement there is a clause: 'IN WITNESS WHEREOF, he parties hereto have executed this Agreement on the date first written above.'

Table 1: Summary of the existing datasets and the *Kleister* sets.

Dataset name	CoNLL 2003	WikiReading	FUNSD IC- DAR 2019	SROIE IC- DAR 2019	Kleister- NDA	Kleister- Charity
Source Annotation Documents Entities	manual 1 393 35 089	WikiData/ Wikipedia automatic 4.7M 18M	scanned forms manual 199 9 743	scanned receipts manual 973 3 892	manual 540 2 160	UK Charity Commission semi-automatic 2 778 21 612
train docs dev docs test docs	946 216 231	16.03M 1.89M 0.95M	149 	626 — 347	254   83   203	1 729 440 609
Entity classes	4	867 (top 20 cover 75%)	3	4	4	8
Mean pages/doc Mean words/doc Mean enti- ties/doc	216.4 25.2	1/Wikipedia article 489.2 5.31	1 158.2 49.0	1/receipt 45 4	5.98 2540 4.0	22.19 5149 7.8
Complex layout	N	N	Y	Y	Y/N	Y/N

Table 2: Summary of the entities in the NDA and Charity datasets.

Entities	Description	Total	% all entities			
	NDA dataset					
party	parties appearing in the agreement (each of them is treated as a separate entity)	1035	47.9			
jurisdiction	state or country whose law governs the agreement	531	24.6			
effective_date	date on which the contract becomes legally binding	400	18.5			
term	duration of the agreement	194	9.0			
	Charity dataset					
addresspost_town	post town (part of a charity address)	2692	12.5			
addresspostcode	postcode (part of a charity address)	2717	12.6			
addressstreet_line	street with the house number (part of a charity address)	2414	11.1			
charity_name	name of the charitable organization	2778	12.9			
charity_number	identification number in the charity register	2763	12.8			
report_date	date of reporting	2776	12.8			
income_annually	annual income in British pounds (GBP)	2741	12.7			
spending_annually	annual spending in British pounds (GBP)	2731	12.6			

## 3.2 Charity Dataset

The Charity dataset consists of annual financial reports that all charities registered in England and Wales are required to submit to the Charity Commission for England and Wales. Then, the Commission makes them publicly available via its website.<sup>5</sup> Charity reports were collected from the UK Charity Commission website, just like annotations to these documents. The entity list was established on the basis of information that we were able to automatically obtain from the tables on the page describing the content of the reports<sup>6</sup> (see Table 2).

The quality of automatically obtained entities was checked by a team of annotators based on 100 random reports. After analyzing these documents, the following annotations were corrected: the names of

 $<sup>^5 \</sup>rm https://apps.charitycommission.gov.uk/showcharity/registerofcharities/RegisterHomePage.aspx$ 

<sup>&</sup>lt;sup>6</sup>A detailed description of the data collection method can be found in the Appendix.

# Which date is the effective date?

#### First page:

This Supply, Mutual Confidentiality & Non-Disclosure Agreement is made and entered into this 1st day of November 20, 2008 by and between: BIOSIL LIMITED ("Biosil") a company having its registered office at Global House, Isle of Man Business Park, Cooil Road, Douglas, Isle of Man and a manufacturing operation at 127 Deerdykes View, Westfield Industrial Estate, Cumbernauld, G68 9HN, Scotland.

#### Signature page:

Biosil, Ltd.	Applied Silicone Corporation
By: /s/ Barry Hatt	By: /s/ Alastair Winn
General Manager, Biosil	Alastair Winn, President
December 17, 2008	December 18, 2008

# Which address is the charity address? Which number is the charity number?

Registered Office:  Principal Address:	11c Grosvenor Way London E5 9ND 43 Heathland Road	Status Breast Cancer Now is a company limited by guarantee, governed by Articles of Association, registered in England and Wales (number 9347608) and registered as a charity in England and Wales (number 1160558), Scotland (SC045584) and Isle of Man (number 1200). The Trustees listed on page 45 are also the charity's
Timepu/Kuress.	London N16 5PQ	Directors and have overall responsibility for the strategic direction and effective governance of the charity. The Trustees met regularly during the year.

Figure 2: Examples of problematic entities in documents from the Kleister-NDA and Charity datasets.

the organizations (normalization of Ltd.) and amounts (we fixed entities by adding a decimal part of the value) in a part of the development set and in the whole test set (development and test sets are important in context of measuring model actual performance). Then we repeated the annotation check based on 200 random documents from train and development sets (we assume that the annotation of the test set is excellent— $\kappa = 0.848^7$ ). Our preliminary and final results of the quality control procedure are presented in Table 2. The results for the train dataset are definitely lower, but at the same time this set is four times larger than the two others and, unlike them, only a small part of it was manually annotated.

Table 3: Results of the manual verification of Charity dataset.

Entities	Correct initial annotations[%] entire dataset	Correct final annotations [%] train dev test $(\kappa)$		
			02	
address (as a whole)	23	55	93	0.920
addresspost_town	<del></del>	83	99	0.889
addresspostcode	_	78	98	1.000
address_street_line	<del>_</del>	67	93	0.871
charity_name	86	81	92	0.904
charity_number	99	95	100	0.492
charity_date	99	98	100	1.000
income_annually	82	90	91	0.906
spending_annually	78	86	92	0.725

Figure 2 shows problems with two entities in reports of the charitable organization: charity address and number. Both can co-occur in many variants for the same organization and in the same document. In these cases, it was necessary to refer to the business logic, so the correct answers are "Registered address" and charity number for England and Wales.

<sup>&</sup>lt;sup>7</sup>Cohen's kappa coefficient was calculated on the basis of double annotation of 100 random documents from the set test.

## 4 Baseline models

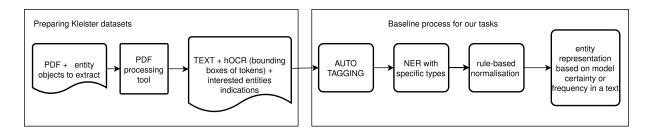


Figure 3: Our process of preparing Kleister datasets and training baselines. Initially, we gathered PDF documents and required entities' values; an important part of the process is the OCR. Then, based on only textual data we prepare pipeline solutions. The pipeline process is illustrated in the second frame and consists of the following stages: auto-tagging, standard NER, text normalization, final selection of the values of entities.

Kleister datasets for information extraction are challenging tasks and do not exactly match any existing solutions in the current NLP world. In this paper, our aim is to produce strong baselines based on text treated as a sequence, without using additional spatial information. We propose *Pipeline* technique to solve extraction problems. Our baseline *Pipeline* method is a chain of processes with a named entity recognition (NER) model as a crucial one to indicate a given entity in the text, then to normalize the entities to canonical forms and finally to aggregate all results into one, adequate to the given entity type. Contextual String Embeddings ("Flair") (Akbik et al., 2018), BERT-base (Devlin et al., 2018) and RoBERTa-base (Liu et al., 2019b) models are used for this. Moreover, we tried different PDF processing tools for text extraction from PDF documents to check importance of text quality to final score of the system.

# 4.1 Pipeline

The core idea of this method is to select specific parts of the text in a document that denote the objects that we are looking for. The whole process is presented in Fig. 3 with the following stages:

- 1. **Auto-tagging**: this stage involves extracting all the fragments that refer to the same or different entities by using sets of regular expressions combined with a gold-standard value for each general entity type (date, organization, amount, etc.), e.g. when we try to detect a report\_date entity, we must handle different date formats: 'November 29, 2019', '11/29/19' or '11-29-2019'. This step is performed only during training (to get data on which a NER model can be trained).
- 2. **Named Entity Recognition**: using the auto-tagged dataset, we train a NER model<sup>8</sup> and then, at the evaluation stage, we use it for the detection of all occurrences of entities in the text being processed.
- 3. **Normalization**: at this stage objects are normalized to the canonical form which we have defined in the *Kleister* datasets. We use almost the same regular expression as during auto-tagging, e.g. all detected report\_date occurrences are normalized from: 'November 29, 2019', '11/29/19' and '11-29-2019' into '2019-11-29'.
- 4. **Aggregation**: we produce a single output from multiple candidates detected by the NER model. In our case, the technique is simple: we return the object with the maximum summarized scores grouped by the normalized forms of the extracted entities.

Certainly, almost each stage of the above process can be done with a wide range of techniques, from regular expressions to more advanced machine learning models and deep neural networks.

<sup>&</sup>lt;sup>8</sup>Note that this is not a general NER model for addresses, dates, amounts, etc., but rather for more specific data-point types: charity addresses, report dates, incomes, etc.

# 4.1.1 Pipeline based on Flair

The Flair model (based on stacked char-Bi-LSTM language model and GloVe word embeddings (Pennington et al., 2014)) is used as an encoder and Bi-LSTM with a CRF layer—as an output decoder. Based on many experiments on the NDA and Charity development datasets, we found out the best setup for parameters, which is:  $learning\ rate = 0.1$ ,  $batch\ size = 32$ ,  $hidden\ size = 256$ , epoch = 30/15 (NDA/Charity), patience = 3,  $anneal\ factor = 0.5$  and with a CRF layer on the top. Moreover, each document was split into chunks of 300 words with overlapping parts of 15 words. Results from overlapping parts were normalized into one by using the mean of probabilities for each word from both overlapping parts.

## 4.1.2 Pipeline based on BERT/RoBERTa

The BERT/RoBERTa models are fine-tuning approaches based on the Bidirectional Encoder Representations from Transformers language model. We found out the best experimental setup, which is:  $learning\ rate=2e-5$ ,  $batch\ size=8$ , epoch=20, patience=2 after many experiments on the NDA and Charity datasets for both models. Moreover, each document was split into chunks of 510 tokens (plus two special tokens: [CLS] and [SEP]) with overlapping parts of 100 tokens. Results from overlapping parts were normalized into one by using the mean of probabilities for each token from both overlapping parts.

## 4.2 PDF processing tools

PDF documents are input for Kleister challenges, from which we must extract text for further processing. Thus, an important role in whole system and final score of the *Pipeline* approach will be accuracy of the tool that we use. Therefore, we checked performance on three PDF processing tools and one combination of them:

- 1. Tesseract (Smith, 2020) in version 4.1.1-rc1-7-gb36c<sup>11</sup>. This is the most popular free OCR engine currently available.
- 2. Textract with API version from March 1, 2020<sup>12</sup>. One of the most recognizable OCR tools and an open-source competitor of Tesseract.
- 3. pdf2djvu/djvu2hocr in version 0.9.8<sup>13</sup> (later we will call that method *pdf2djvu*). Free tool for object extraction (and text extraction) from born-digital PDF files.
- 4. pdf2djvu+Tesseract is a combination of pdf2djvu/djvu2hocr and Tesseract. Documents are processed with both tools, by default we take the text from pdf2djvu/djvu2hocr, unless the text returned by Tesseract is 1000 characters longer. This is a simple and efficient way to merge PDF processing solutions for extracting text from scans and born-digital PDF files.

## 4.3 Results

## 4.3.1 Text extraction methods

Results of the performance of different PDF processing tools are presented in Table 4. The general conclusion is that by using software with the best text extraction methods we could achieve much better results, but we still cannot resolve all problems connected to information extraction task.

The best tool for born-digital documents in *Kleister-NDA* challenge for all models is a pdf2djvu tool. We should expect it, thus that documents are without any text errors normally caused by using OCR engines which are not perfect yet. For *Kleister-Charity* challenge the best tool is Textract with huge advantage on all models, especially flair based. In the next sub-section, we describe in detail baseline results based on the most accurate PDF processing tool for each Kleister task.

<sup>&</sup>lt;sup>9</sup>We used implementation from the Flair library (Akbik et al., 2018) in version 0.4.5.

<sup>&</sup>lt;sup>10</sup>We used implementation from *pytorch-transformers* (Hugging Face, 2019) library.

<sup>&</sup>lt;sup>11</sup>We ran it with --oem 2 -1 eng --dpi 300 flags (meaning both new and old OCR engines were used simultaneously, and language and pixel density were forced for better results)

<sup>12</sup>https://aws.amazon.com/textract/

<sup>13</sup>http://jwilk.net/software/pdf2djvu,https://github.com/jwilk/ocrodjvu

Table 4: Performance of different PDF processing tools checked on *Kleister* challenges test-sets. All results are f-scores over 3 runs with standard deviation. (\*) pdf2djvu does not work on scans, so we have empty 54/24/21 documents in train/dev/test sets.

Kleister-NDA dataset (born-digital PDF files)							
PDF processing tool Flair BERT-base RoBERTa-base							
pdf2djvu	$\textbf{77.70} \pm \textbf{0.01}$	72.17 $\pm$ 1.07	77.07 $\pm$ 1.61				
Tesseract	$75.17 \pm 0.12$	$68.30 \pm 0.41$	$74.20 \pm 1.90$				
Textract	$75.63 \pm 0.17$	$70.43 \pm 1.11$	$76.20 \pm 0.64$				
Kleister-Cha	urity dataset (mixture of	f born-digital and scans	PDF files)				
pdf2djvu (*)	$71.80 \pm 0.35$	$67.53 \pm 0.71$	$72.50 \pm 0.49$				
Tesseract	$72.87 \pm 0.81$	$71.37 \pm 1.25$	$75.70 \pm 0.57$				
Textract	$\textbf{80.10} \pm \textbf{0.35}$	$\textbf{73.30} \pm \textbf{0.43}$	$\textbf{79.87} \pm \textbf{0.65}$				
pdf2djvu+Tesseract	$74.00 \pm 1.28$	$70.47 \pm 0.26$	$75.63 \pm 0.68$				

#### 4.3.2 NER models

The results for the two Kleister datasets obtained with the *Pipeline* method based on Flair, BERT and RoBERTa models are shown in Table 5. The differences in F-score between Flair and RoBERTa models are not substantial in both challenges. Moreover, the RoBERTa model is much better as far as amounts (income\_annually and spending\_annually entities in Charity dataset) and organization names (party entity in NDA dataset and charity\_name entity in Charity dataset) are concerned.

The most challenging problems for all models are types related to the business reasoning (e.g. in NDA term or address\_\_\*), the visual features (e.g. in Charity income and spending) and finally hard normalization (e.g. in Charity charity\_name). We can also observe that the entities appearing in the sequential contexts achieve a higher F-score. Moreover, after analyzing the model results, we prepared a list of common problems in models, which we grouped into specific problem categories (see Table 6).

Table 5: Results of our baselines for *Kleister* challenges test-sets. Results for all models are f-scores over 3 runs with standard deviation. Human baseline is a percentage of annotators agreements for 100 random documents.

Kleister-NDA dataset (pdf2djvu)						
Entity type	Flair	BERT-base	RoBERTa-base	Human baseline		
effective_date party jurisdiction term	$82.03 \pm 1.72$ $70.13 \pm 0.11$ $93.80 \pm 0.42$ $60.82 \pm 26.7$			100 % 98 % 100 % 95 %		
ALL	$\textbf{77.70} \pm \textbf{0.01}$	$  72.17 \pm 1.07$	$77.07 \pm 1.61$	97.86%		
	Kleister-	Charity dataset (Textr	act)			
addresspost_town addresspostcode addressstreet_line charity_name charity_number income_annually report_date spending_annually	$83.30 \pm 3.81$ $82.63 \pm 0.54$ $68.17 \pm 4.36$ $72.40 \pm 0.98$ $96.73 \pm 0.12$ $70.93 \pm 0.43$ $95.67 \pm 0.00$ $68.50 \pm 0.26$	$\begin{array}{c} 73.57 \pm 2.49 \\ 79.00 \pm 0.65 \\ 61.33 \pm 2.74 \\ 73.53 \pm 3.16 \\ 96.43 \pm 0.52 \\ 69.97 \pm 1.68 \\ 94.97 \pm 0.38 \\ 67.30 \pm 1.36 \end{array}$	$ 77.70 \pm 1.27 $ $82.57 \pm 0.56 $ $63.80 \pm 3.27 $ $76.87 \pm 0.37 $ $96.13 \pm 0.45 $ $73.20 \pm 0.64 $ $95.53 \pm 0.12 $ $71.27 \pm 0.84 $	98 % 100 % 96 % 99 % 98 % 97 % 100 % 92 %		
ALL	<b>80.10</b> ± 0.35	$  77.30 \pm 0.43$	$  79.87 \pm 0.65$	97.45 %		

## 5 Discussion and Challenges

In Table 1, we gathered the most important information about open datasets, especially we outlined the difference between our datasets and other sets. Additionally, we prepared descriptions of problems related to Kleister tasks (see Table 6). Thus, the *Kleister* datasets appear to be more focused on the

real life examples, where layout, document-level context, OCR quality, business logic and normalization problems need to be resolved for obtaining good results.

Summing up, the proposed datasets are useful for testing real life applications to solve the challenge of the robotic process automation tackled by machine learning techniques.

Table 6: Common prol	blems in <i>Kleister</i>	datasets with	ı examples.
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	Table 6. Common problems in Kleister datasets with examples.
	<b>Normalization</b> : Differences in the way entities are given in expected values and documents.
NDA	effective_date: October 24, 2012, 10/24/12 or 24th day of October, 2012 term: 2 years, 24 months, two (2) years, two years or second anniversary
Charity	charity_name: 1. Ltd vs Limited: King's Schools Taunton LTD [expected] vs King's Schools Taunton Limited [document]; 2. The vs non-The: The League of Friends of the Exmouth Hospital [expected] vs League of Friends of Exmouth Hospital [document]
	Layout: understand complex layout properly
NDA	all entities: four types of layout: 1. Simple layout (one column), 2. Simple layout (two columns), 3. E-mail, 4. Plain text. See Fig. 4 in the Appendix.
Charity	all entities: three types of layouts: 1. Simple document, 2. Report with tables, graphic elements and pictures, 3. Form. See Fig. 1.
	Document-level context: understand document as a whole
NDA	term: The term informs about the duration of the contract. Information on this is generally found in the "Term" chapter. However, this section may also include other periods of validity of certain provisions of the contract.
	Example: "Term. This Agreement will be effective for a period of one (1) year after the Effective Date. The restrictions on use and disclosure of the Discloser's Confidential Information by the Recipient shall survive any expiration or termination of this Agreement and shall continue in full force and effect for a period of five (5) years thereafter."
Charity	income_annually, spending_annually: Co-occurrence of exact and rounded values in one document. See Fig. 7 in the Appendix
	Business logic: apply some rules in a case of ambiguity
NDA	term: Co-occurrence of two terms in one document. In such a case, the one constituting the duration of the renewed contract was considered inappropriate.  Example: 'Term; Termination. The term of the employment agreement set forth in this shall be for a period commencing at the Effective Date and continuing for three (3) years thereafter (the "Scheduled Term"). Following the Scheduled Term, the Agreement shall automatically renew for successive one-year terms (each a "Renewal Term").'
Charity	address*: Co-occurrence of different addresses (e.g. Principal address, Registered office, Administrative address, etc.) next to each other in one document, or the lack of a clear identification of the charity's address. In such a case the Registered address was considered to be the main one. See Fig. 2.
	OCR quality: process scan documents
NDA	N/A — born-digital documents.
Charity	all entities: Handwriting in the document, pages upside down or poor scan quality.

As described above, working with the proposed datasets can be compared to challenges dealing with Information Retrieval and Natural Language Understanding, including challenges related to page layout understanding (i.e. tables, rich graphics, etc.). To solve these challenges, we presented the *Pipeline* approach that will help to deal with specific problems.

Most of these stages are described in the process of building baselines and are shown in Fig. 3.

Using the presented challenges we are also able to study the impact of each stage of the full process on the final results. It is useful in the production environment where we can have a baseline, and then we can assess what should be done with the highest priority to improve final results.

#### 6 Conclusions

Kleister datasets have been prepared to challenge the business usability of Information Extraction models and processes. In this article, we described in detail how they were prepared (i.e. manually or automatically — for Kleister-NDA and Kleister-Charity respectively). Due to their multi-modal nature, we had to face various problems and needed to develop methods to improve the quality of data sets.

We consider our datasets and tasks will help the community to extend the understanding of documents with substantial length, various reasoning problems, complex layouts and OCR quality problems. Moreover, the community can use our methodology to extend the datasets or prepare similar sets.

In addition, we prepared baseline solutions on the basis of text data generated by different PDF processing tools from the datasets (see Table 4). This benchmark shows weakness of the models working on a pure text (i.e. input is a sequence of words) without using any visual information.

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# **Appendix**

In this supplement we describe more precisely our datasets and the annotation processes in Section A and Section B, respectively.

## A NDA Dataset

## A.1 Data Detailed Description

The NDA agreements prevent the disclosure of confidential information by one of the parties to a third party. Such agreements, even in oral form, are often found in everyday life (e.g. in the patient-doctor relationship). In business, they usually have a written form, signed by a representative of the legal profession and another person (legal or natural). In our database, we have collected business contracts, but without differentiating them, either by their form (these are both independent contracts and contracts annexed to other contracts), or by the way they were concluded (all contracts were concluded in writing, some of them by e-mail) or because of the number of parties (the dataset contains unilateral, bilateral and multilateral agreements).

The NDAs can take various forms (contract attachments, emails, etc.), but they all generally have a similar structure. First, the circumstances of the contract are determined, i.e. the parties to the contract are presented and the date from which the contract becomes effective is provided. Then they usually contain the following elements:

- a definition of confidential information, including exceptions to this definition;
- description of the disclosure procedure (also during court and administrative proceedings);
- procedures related to non-compliance with confidentiality obligations;
- term of the contract (termination date);
- the period during which the information remains confidential (confidential period);
- information about the jurisdiction to which the contract is subject;
- information about the possibility of making legally binding copies of the contract;
- due to the fact that confidential information can be used to recruit new employees or contractors of
  one party by another, the NDA often also includes non-compete clauses in force for a certain period
  of time.

#### A.2 Data Collection Method

During the collection of the NDAs, we focused on contracts concluded by public companies in the United States. All public companies (i.e. those with shareholders) in the US are supervised by the United States Securities and Exchange Commission (SEC). Companies are required to submit a number of reports and forms, the attachments of which are often contracts concluded by these companies, including NDAs. This is done through the Electronic Data Gathering, Analysis and Retrieval system (EDGAR), which is also a public database of these documents (these documents must be made public)<sup>14</sup>. As a result, EDGAR is a huge NDA base. Unfortunately, NDAs are usually attachments to other contracts or forms submitted to EDGAR, as a result of which it is not possible to simply aggregate them from this database. Thus, the process of gathering the dataset had to be manual, with a weak model supervision.

The NDAs were collected with the help of the Google search engine. Two collections were created—the first contained 170 contracts and the second 330 contracts, except that 117 duplicates were found, so that ultimately the dataset counted a total of 383 documents. After the first tests on the already annotated dataset, it turned out that machine learning models achieve quite poor results for information

<sup>14</sup>https://www.sec.gov/edgar.shtml

First page:		First page:	
COVENANT NO AND NON-DISCLOS	TO COMPETE URE AGREEMENT	MUTUAL NONDISCI	LOSURE AGREEMENT
PARTIES:		This Mutual Nondisclosure Agreement (this "Agreement") is ente corporation ("Yahoo") and the undersigned entity ("Counterparty"). Yaho	ered into this 2nd day of July, 2011, by and between Yahoo! Inc., a Delaware
Charles D. Denson (EMPLOYEE) and		In connection with our mutual consideration of a possible	does not include information which (i) is or becomes generally
NIKE, Inc., and its parent, divisions, subsidiaries and affiliates. (NIKE):		strategic transaction (a "Transaction") Yahoo and Counterparty expect to make available to one another certain information concerning their	available to the public other than as a result of a breach of this Agreement by the receiving party or its Representatives; (ii) was within
RECITALS:		respective businesses including, but not limited to, technology, financial forecasts, financial condition, operations, assets and liabilities and business strategies. As a condition to such information being	the receiving party's possession prior to its being furnished to the receiving party by or on behalf of the disclosing party, provided that to the receiving party's knowledge, the source of such information is not
A. This Covenant Not to Compete and Non-Disclosure Agreement President of the NIKE brand and is a condition of such advancement.	s executed upon the EMPLOYEE's advancement to the position of	furnished to each party and its subsidiaries, directors, officers, employees, agents or advisors (including, attorneys, accountants,	and was not bound at the time of delivery by a confidentiality agreement with, or other contractual, legal or fiduciary obligation of
B. Over the course of EMPLOYEE's employment with NIKE, EMI confidential information peculiar to NIKE's business and not generally kno	PLOYEE will be or has been exposed to and/or is in a position to develop wn to the public as defined below ("Protected Information"). It is	consultants, bankers and financial advisors) (collectively, "Representatives"), each party agrees to treat all Evaluation Material in	confidentiality to, the disclosing party; (iii) is or becomes available to the receiving party on a non-confidential basis from a source that to the
anticipated that EMPLOYEE will continue to be exposed to Protected Infor	mation of greater sensitivity as EMPLOYEE advances in the company.  ure of any Protected Information would result in severe damage to NIKE	accordance with the provisions of this Agreement, and to take or abstain from taking certain other actions hereinafter set forth.	receiving party's knowledge, is not and was not bound at the time such information becomes available by a confidentiality agreement with, or other contractual, legal or fiduciary obligation of confidentiality to, the
and be difficult to measure.	•	Evaluation Material. The term "Evaluation Material" shall be deemed to include all information concerning the other party (whether	disclosing party with respect to such information; or (iv) is independently developed by the receiving party without use of
<ul> <li>NIKE makes use of its Protective Information throughout the we anywhere in the world.</li> </ul>	rld. Protective Information of NIKE can be used to NIKE's detriment	prepared by the disclosing party or its Representatives) which is furnished to a party or to its Representatives in connection with the parties' evaluation of a possible Transaction, in each case by or on	Evaluation Material.  2. Use of Evaluation Material. Each party hereby agrees that it and
AGREEMENT: In consideration of the foregoing, and the terms and conditions set forth bel	now the parties agree as follows:	behalf of the disclosing party in accordance with the provisions of this Agreement. The term "Evaluation Material" also shall include all	its Representatives shall use the other's Evaluation Material solely for the purpose of evaluating a possible Transaction between the parties.
Covenant Not to Compete.	ow, the parties agree as follows.	notes, analyses, compilations, studies, interpretations or other documents prepared by each party or its Representatives which contain, reflect or are based upon, in whole or in part, the information	Each party and its Representatives will keep the Evaluation Material confidential and will not disclose for any purpose any of the other's Evaluation Material in any manner whatsoever; provided, however,
<ul> <li>(a) <u>Competition Restriction</u>. During EMPLOYEE's employ and for twelve (12) months thereafter, (the "Restriction Period"), EM</li> </ul>	ment by NIKE, under the terms of any employment contract or otherwise, PLOYEE will not directly or indirectly, own, manage, control, or	contain, reflect of are based upon, in whole of in part, the information furnished to such party or its Representatives pursuant hereto which is not available to the general public. Notwithstanding the foregoing, the	that (i) the receiving party may make any disclosure of such information to the extent to which the disclosing party gives its prior
participate in the ownership, management or control of, or be employ engaged anywhere in the world in the athletic footwear, athletic appar	ed by, consult for, or be connected in any manner with, any business el or sports equipment and accessories business, or any other business	term "Evaluation Material"	written consent and (ii) any of such information
which directly competes with NIKE or any of its parent, subsidiaries examples of NIKE competitors include, but are not limited to: Adida Saucony, New Balance, Ralph Lauren/Polo Snort, B.U.M. FURIL Th			1
Authority, Columbia Sportswear, Wilson, Mizuno, Callaway Golf and portion of the Restriction Period as more specifically provided below.	Titleist. This provision is subject to NIKE's option to waive all or any		
(b) Extension of Time. In the event EMPLOYEE breaches the toll from the date of the first breach, and all subsequent	is covenant not to compete, the Restriction Period shall automatically		
COVENANT NOT TO COMPETE AND			
NON-DISCLOSURE AGREEMENT - Page 1			
Signature page:		Signature page:	
(d) Applicable Law/Jurisdiction. This Agreement, and EM	PLOYEE's employment hereunder, shall be construed according to the he jurisdiction of, and agrees that exclusive jurisdiction over and venue	Please confirm your agreement with the foregoing by signing and	returning one copy of this Agreement to the undersigned, whereupon this indersigned Counterparty. This Agreement may be executed by a facsimile
for any action or proceeding arising out of or relating to this Agreem  EMPLOYEE	ent shall lie in the state and federal courts located in Oregon.  NIKE, Inc.	signature.	
By: /s/ CHARLES D. DENSON	By: /s/ PHILIP H. KNIGHT	IN WITNESS WHEREOF, the parties hereto have executed this A	greement as of the date first written above.  Yahoo! Inc.
Name: Charles D. Denson	Name: Philip H. Knight	•	By: /s/ Marcus Shen
Title: President, NIKE Brand  DATE: 3.26.01	Title: President & CEO		Name: Marcus Shen Title: Head of Corporate Development Farsimile: 408, 349, 7721
5.20.01			Interclick, Inc. Inc.
COVENANT NOT TO COMPETE AND NON-DISCLOSURE AGREEMENT - Page 4			By: /s/ Michael Katz
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COVENANT NOT TO COMPETE AND NON-DISCLOSURE AGREEMENT - Page 4			Name: Michael Katz
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First page:  Effective as of February 23, 2009  Kenneth M. Bate 33 Middle Street.  Concrord, MA 0.1742  Dear Ken:  Effective immediately prior to the closing of the Merger (as sure of Stamusy 27, 2009, by and among NitroMed, Inc. ("NitroMed"), NTM Design Franci. L. P. Deerfield Private Design International L. P. Deerfield International Line of Concrord, MA 0.1742  Dear Ken:  Effective immediately prior to the closing of such Merger; the time of such closing its referred to herein as the "Effective Date."  NitroMed. as amended by that certain items agreement dated as of Decemper of the Concrord of the Concrording of the Merger; the time of such closing its referred to herein as the "Effective Date."  1. Separation Benefits. Reference is hereby made to that certain prior to the Effective Time. NitroMed is required to provide you with the without limitation the benefits set forth in Section 4.2 thereof.  2. Other Agreements. You hereby reaffirm your obligations previously executed between NitroMed and you (attacked hereto as Edit by any and all commonlos and proprietary documents and information.  3. Release. You hereby acknowledge and agree that by signing paragraph 1 above, you are waiving our right to assets, and releasing Nubrasover from the beginning of time through and including the Effect claim, charge, complaint or any other form of artisic (polity) referred to recovery.  Signature page:  INVENTION AND NON-DE	Parent Acquisition Corp., NTMO Acquisition Corp., Deetfield Private people of Section Studies To Manda Control Private of Section Studies To Manda Control Private of Section Studies of Section Studies (Section Section Sect	PARTIES: The Agreement is between Taro To Company (TACO) and Mit home type does do see of this blow. Z. Before GOLD MAD THE PROPERCY OF indicated (the "Projectity"), family which TACO may death TACO may death of the Company of the Taron (Taron See of the Company of the Taron See of the Company of the Taron See of the Company of the Co	Name: Michael Kazz Title: Chief Esecutive Officer Facctimile: 646-558.1223  50  100 IEEE II OCAN EENTIALITY AND NON-DESCLOSURE AGREEMENT 1  STREET IS CONFERENTIALITY AND NON-DESCLOSURE AGREEMENT 1  STREET IS STREETING, the Advance Revenyor Company ("COMPANY"), such STREETING IN THE STREETING IN
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Figure 4: Four different examples of layouts from the NDA-charity dataset.

on jurisdiction. Analysis of the dataset showed that this was due to the under-representation of documents that were prepared in accordance with non-US law (e.g. China, India or Israel). Since no more such documents were obtained, the 68 previously obtained ones were removed from the dataset, which reduced it to 315 documents. In the next step, the collection was supplemented with an additional 127 documents consistent with the others in terms of applicable law (i.e. US law).

The original files were HTML documents, but they were transformed into PDF files to keep processing

simple and similar to how other datasets were created. Transformation was made using the puppeteer library, which in turn used the "Print to PDF" functionality present in the Chrome web browser. Subsequently, the transformed PDFs were processed with the Tesseract OCR engine.

#### A.3 Annotation Procedure

The whole dataset was annotated in two ways. Its first part, i.e. 315 documents, was annotated by linguists, except that only selected contexts, preselected by an in-house system based on semantic similarity, were taken into account (to make the annotation easier and faster). The second, i.e. 127 documents, was entirely annotated by hand. When preparing the dataset, we wanted to find out if the semantic similarity methods could be used to limit the time it would take to perform annotation procedures (this solution saved about 50% of the time compared to fully manual annotation).

The annotation of the dataset consisted of listing the extracted entities. The entities themselves may appear repeatedly in the document, but this did not matter for the annotation procedure (contrary to NER, we are not interested in the exact location(s) of an entity). The following entities have been normalized according to standards adopted by us: (a) parties — commas have been removed before acronyms referring to organization types, and the format has been unified, e.g. *LHA LONDON LTD*; (b) effective date — the format has been standardized according to ISO 8601, i.e. YYYY-MM-DD; (c) terms — standardized to the following format: number of units followed by a unit, e.g. 2 years; (d) jurisdiction and counterparts did not require standardization. Then the annotations were checked by the super-annotator on 45 random documents (10% of the whole dataset). All the super-annotated entities were correct and did not need to be changed.

# **B** Charity Dataset

## **B.1** Data Detailed Description

There is no rule about how such a charity report should look. Therefore, some take the form of reports richly illustrated with photos and charts, where financial information constitutes a small part of the entire report, while others have only a few pages, where only basic data on revenues and expenses in a given calendar year are given (see Figure 5). However, each of these reports should contain at least the following information (although there may be exceptions to this rule):

- organization's address, name and number;
- the date of submission of the report;
- total income in the reporting year;
- total expenditure in the reporting year.

#### **B.2** Data Collection Method

The decision to create a dataset from the financial reports of British charities was driven by the following goal: to find a publicly available collection of English-language and multi-page documents on the Internet, which would be accompanied by easy-to-extract information about data contained in these documents (e.g. as a separate XML file or a table on a website). We decided that the database of financial reports of British charity organizations would be the best of all the options considered. It is not just that the Charity Commission website actually has a database of all the charity organizations registered in England and Wales, but also that each of these organizations has a separate subpage on the Commission's website and it is easy to find the most important information about them (see Fig. 5):

- Charity's name and number;
- main activities;
- current address parts (post town, postcode and street line);

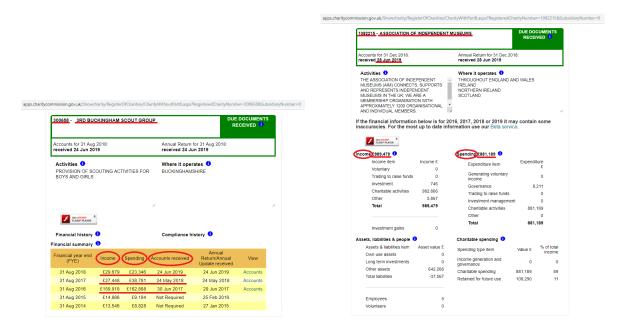


Figure 5: Organization's page on the Charity Commission's website (left: organization whose annual income is between 25k and 500k GBP, right: over 500k). Information on the website has a different layout, and within documents there is also the case. Entities are underlined in red and names of entities are circled.

- a list of the current trustees of the organization;
- basic financial data for the past year, i.e. income and expenditure (these data are more detailed in the case of organizations with revenues of over 500,000 GBP a year);
- the date of submission of the report.

This information partly overlaps with what the reports actually contain (although it might happen that some entities are not to be found in the reports, e.g. a list of trustees is given on the website, but it does not have to be included in the report). For this reason, we decided to extract only those entities which also appear in the form of a brief description on the website.

The reports can be found on the website as PDF files (but this does not apply to organizations with income below 25,000 GBP a year, as they are required to submit a condoned financial report). Therefore, the information available on the website and the documents attached to it made the database of these documents perfectly fit the objectives outlined above. In this way, 3414 documents were obtained.

During the analysis of the documents, it turned out that several reports are in Welsh. As we are interested in the English language only, all documents in other languages were found and removed from the collection. In addition, documents, that contained reports for more than one organization, were handwritten, or the quality of their OCR was low, were deleted. As a result, the collection has 2778 documents.

# **B.3** Annotation Procedure

There was no need to manually annotate documents, because basic information about the reporting organizations could be obtained directly from the website where these documents were located.

Only a random sample of 100 documents was manually checked (see Table 7). The permissible error limit for a given entity was set at 15%. These results were exceeded for charity name (18% of errors and minor differences) and for charity address (76% of errors and minor differences). However, as a result of detailed analysis, it turned out that there are few erroneous entities (respectively 5% and 9%), while the rest is rather due to differences in the way the data is presented on the page and in the document. These minor differences have been corrected manually and automatically, as described below.

Table 7: Comparison of data on the Charity Commission's website and in charity reports.

Entities	Correct [%]	Minor differ- ences [%]	Error [%]
charity_name	82	13	5
charity_address	24	67	9
charity_number	98	0	2
report_date	99	0	1
income_annually	86	$3^{15}$	11
spending_annually	86	$3^{16}$	11

Hence, the charity's name on the website and in the documents could be noted once with the term *Limited* (shortened to *LTD*), and once not. This problem was eliminated by the manual annotation of all documents in which the name of the charity organization co-occurred with the word *Limited* or *LTD*. As a result, 366 documents were analyzed manually in this way.

In the case of the charity's address the most problematic were the names of counties, districts as well as the names of towns and cities, which were once specified on the website, but not in the documents, other times—the other way round. This problem was solved by splitting address data into the three separate entities that we considered the most important—postcode, postal town name and street or road name. The postal code was used as the key element of the address, on the basis of which the city name and street name could be determined<sup>17</sup>.

Other problems show Fig. 6 and 7. On the first of them we have two different values for income\_annually and spending\_annually, because the values in the table are rounded and in the text are accurate. In the second picture there is no total for all expenses, so we can not extract the value for spending\_annually.

	Univestric	ted Funds	Restricted	Endowment	Total	Total
	Capital	Acc Income	Funds	Funds	2018	2017
	£	£	£	£	£	£
Income and Endowments from						
Stocks and shares		155,387	2,034	3,987	151,408	154,192
Deposit interest		116	2	3	121	268
Total Income and Endowments		155,503	2,036	3,990	161,529	154,460
Expenditure on						
Charitable activities (note 9)	-	(124,922)	(1,000)	(247)	(126,169)	(129,367)
Generating funds						0.0000000
Investment management charges	(19,911)	120	-	-	(19,911)	(17,590)
					?	
Net gains/(losses) on investments	(18,655)	19	(244)	(479)	(19,378)	719,832
Net Income/(expenditure)	(38,566)	30,581	792	3,264	(3,929)	727,335

Figure 6: No value for spending\_annually.

<sup>&</sup>lt;sup>15</sup>Including two cases of non-rounding of the amount and one filling in the amount in USD instead of GBP.

<sup>&</sup>lt;sup>16</sup>As above

<sup>&</sup>lt;sup>17</sup>Postal codes in the UK were aggregated from a website: streetlist.co.uk

#### Financial Review

The table below summarises the group's financial performance:

	2017/18 £000	2016/17 £000
INCOME		
From customers	12,861	13,229
From customers of subsidiary	183	213
	13,044	13,442
Investment income	5	7
Funding by Kirklees MC	1,656	2,352
Other funding	77	51
	14,782	15,852
EXPENDITURE		
Staff costs, including self-employed instructors	9,241	8,925
Other costs incurred by KAL	6,024	6,414
Costs incurred by KALT	54	90
	<u>15,319</u>	15,429
EXCESS OF EXPENDITURE OVER INCOME, BEFORE THE EFFECTS OF THE DEFINED BENEFIT PENSION SCHEME	(23/)	423
EFFECTS OF THE DEFINED BENEFIT PENSION SCHEME		
Current year charge	(1,122)	(640)
Re-measurement gain/ (loss)	1,299	(3,569)
	<u>177</u>	(4,209)
NET MOVEMENT IN FUNDS BEFORE TAX	(360)	(3,786)
Corporation Tax charge on KALT	(1)	
NET MOVEMENT IN FUNDS AFTER TAX	(361)	(3,786)
FUNDS BROUGHT FORWARD	(6,487)	(2,701)
FUNDS CARRIED FORWARD	(6,848)	(6,487)
Comprising:		
Charity reserves, excluding pension liability	1,853	2,393
Subsidiary reserves	8	6
Total Funds, excluding pension liability	1,861	2,399
Pension deficit	(8,709)	(8,886)
Total Funds	(6,848)	(6,487)

2017/18 was an especially challenging year financially with a huge reduction in funding support from the local authority of £750,000, while significant local competitors to the fitness market also opened new facilities. Given that the local economy remains difficult and wage growth relatively flat, the Charity faced considerable financial challenge, resulting in an outturn position below the planned budget position.

The group's income for the year was £14,781,739 (2016/17 £15,852,553), of which £12,938,544 (2016/17 £13,280,540) was generated through charitable trading activities. The trading subsidiary contributed a further £182,573 (2016/17 £213,321) from its activities.

Total resources expended amounted to £16,440,851 (2016/17 £16,069,445) including costs incurred by the trading subsidiary of £53,697 (2016/17 £89,861).

Before the actuarial effects of the defined benefit pension scheme on the group, net resources expended amounted to £1,659,112 (2016/17 £216,892).

Figure 7: Different values for income\_annually and spending\_annually.