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Text Mining

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Outline

Introduction

Motivation

Text is an extremely rich source of information. For example, each minute, people send hundreds of millions of new emails and text messages.

There is a veritable mountain of text data waiting to be mined for insights. But data scientists who want to glean meaning from all of that text data face a challenge: it is difficult to analyze and process because it exists in unstructured form.

Definition of text mining

Text mining can be defined as:

> *The process of extracting new, previously unknown information from different written resources.*

Written sources can be, for instance, websites, books, e-mails, reviews, articles.

Classical text mining tasks usually involve the process of structuring the input text, deriving patterns within the structured data, and finally evaluating and interpreting the output.

Text fundamentals

In this scope, *text* is defined as a kind of unstructured data consisting of a series of paragraphs, each composed of one or more sentences, each made by strings called words.

Sentences start with a capital letter and end with a full stop. A sentence may have one or several *clauses*, that can be joined to one another by conjunctions or by relative pronouns.

A *paragraph* is an ordered list of sentences consistent with a particular subtopic. Paragraphs start with an indentation and end with a carriage return.

A *word* is considered as the basic text unit. Nevertheless, sometimes words "go together", for instance: can lead to, as well as, in contrast, food waste, environmental problem, ...

Text formats

Text may be stored and processed using different formats, which increases the difficulty of information mining tasks:

- MS Word
- MS Powepoint
- PDF Adobe
- XML
- HTML
- Plain text

Text Preprocessing

Text mining tasks

Typical text mining tasks include:

- Visualization
- Classification
- Clustering
- Tagging/annotation
- Concept/entity extraction
- Sentiment analysis
- Document summarization

However, typically, before any of these tasks, some deal of preprocessing has to be performed over the text.

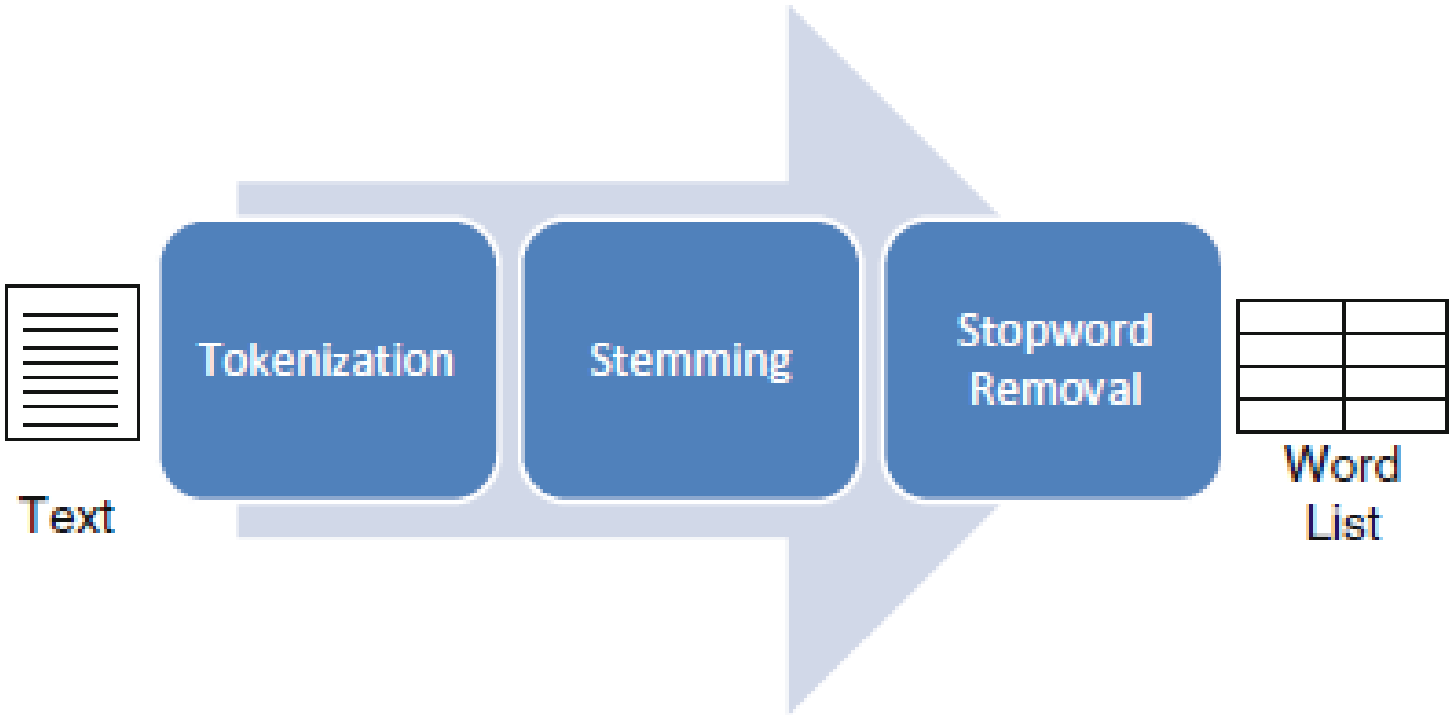
Text preprocessing

Since text is a kind of unstructured data, it is difficult to analyze it in its original form.

To apply classical analysis approaches, we have to describe it by means of a fixed number of attributes.

In this sense, the first step is that of performing *text indexing*, that is, converting texts into a list of words. Then, we have to devise a way to assign an importance score to each word, a task that is named *term weighting*.

Three steps of text indexing



Tokenization

The tokenization process involves segmenting text into tokens.

Tokens are identified by looking at white spaces, punctuation and special characters.

Words with one ore more special characters may be discarded entirely, or just the special characters can be removed (e.g., “25%”).

Words are transformed to lowercase, so to obtain a unique representation for each word.

Tokenization example

Text categorization refers to the process of assign a category or some categories among predefined ones to each document, automatically. Text categorization is a pattern classification task for text mining and necessary for efficient management of textual information systems.

Tokens
text
categorization
refers
to
the
process
of
assign
a
category
.....

Stemming

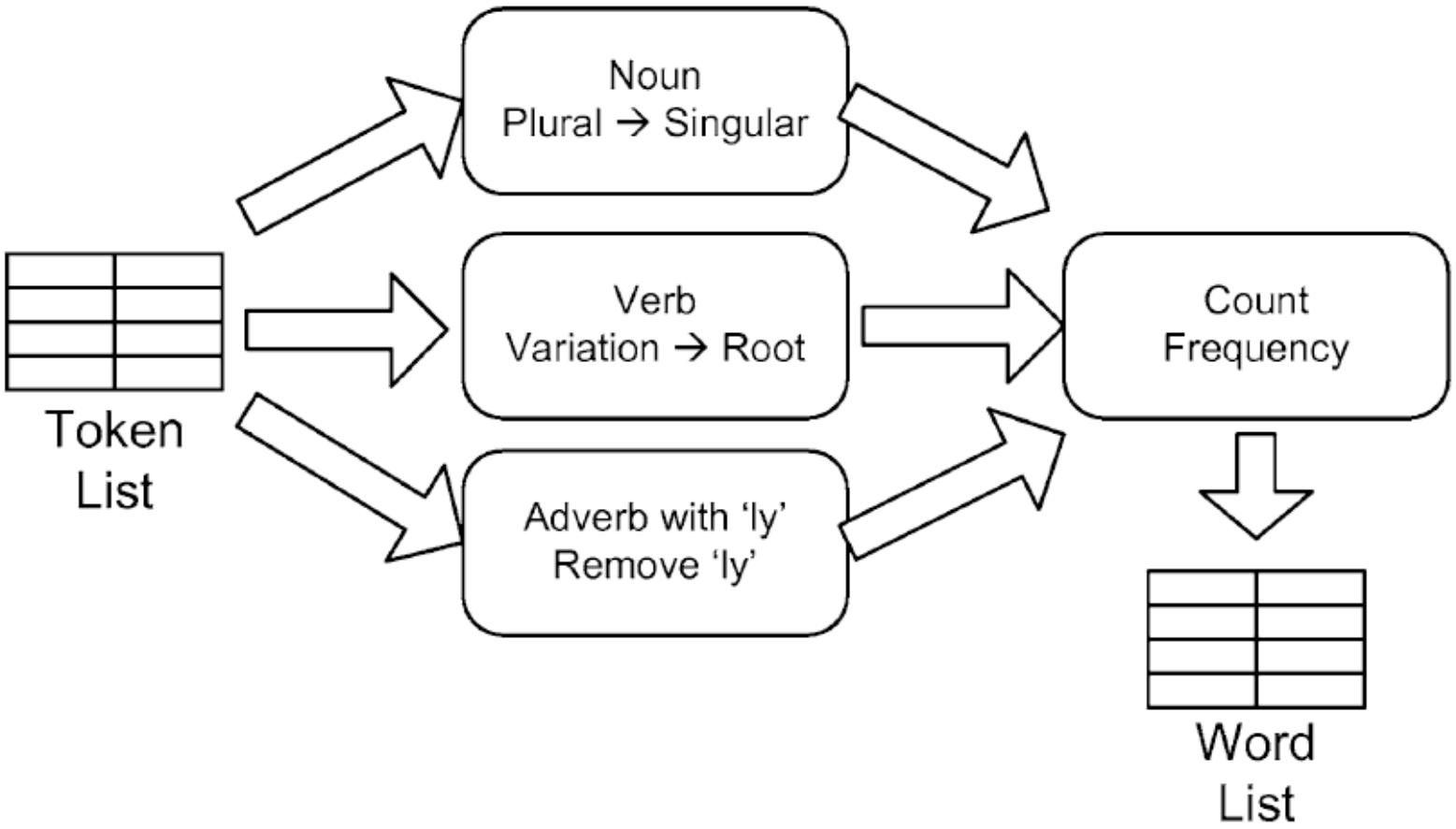
Stemming is the process of mapping each token obtained from the previous step into its root form.

Stemming is usually applicable to nouns, verbs, and adjectives.

The output of this process is a list of words in their root forms.

Language-dependent stemming rules are required for this process (e.g., Porter algorithm).

Stemming Process



Stemming example

Varied Form	Root Form
better	good
best	good
simpler	simple
simplest	simple
assigning	assign
assigned	assign
assignment	assign
complexity	complex
analysis	analyze
categorization	categorize
categorizing	categorize
categorizes	categorize

Stop word removal

Stop word removal is the process of removing stop words from the list of tokens.

Stop words are the most common words in a language, though there is no single universal consensus on them.

Some examples are prepositions, such as 'in', 'on', 'to', and so on. Conjunctions such as 'and', 'or', 'but', and 'however'.

Intuitively, one may want to remove stop words since they do not bring any information, being far too common.

Caveat: in some cases, stop words may actually be important. For instance, consider the English rock band *The Who*. Or, the phrase *I told you that she was not happy*, which may be left with just ['told', 'happy '].

From words to n-grams

Dealing with single words has a major drawback: it is not possible to keep into account the word order and context.

For instance, consider the two phrases, which may look the same if just the set of single words is considered:

- *It seems you were right not inviting him*
- *It seems you were not right inviting him*

An *n-gram* is a contiguous sequence of *n* items from a given sample of text or speech.

By means of n-grams, it is possible to keep better track of words contexts, or to consider to phrasal verbs, such as 'get around', 'pass out', 'carry on'.

n-grams – Example

Full sentence	It does not, however, control whether an exaction is within Congress's power to tax.
Unigrams	"It"; "does"; "not,"; "however,"; "control"; "whether"; "an"; "exaction"; "is"; "within"; "Congress's"; "power"; "to"; "tax."
Bigrams	"It does"; "does not,"; "not, however,"; "however, control"; "control whether"; "whether an"; "an exaction"; "exaction is"; "is within"; "within Congress's"; "Congress's power"; "power to"; "to tax."
Trigrams	"It does not"; "does not, however"; "not, however, control"; "however, control whether"; "control whether an"; "whether an exaction"; "an exaction is"; "exaction is within"; "is within Congress's"; "within Congress's power"; "Congress's power to"; "power to tax."

N-grams and attributes

Starting from all the n-grams extracted from the documents, we then derive the attributes by which to describe the texts.

The idea is that of considering just the n-grams that appear in at least k documents of the collection, to avoid an explosion in the number of attributes.

Each document will then be described in terms of those n-grams.

To such an extent, *term weighting* techniques are employed.

Term Weighting

Term weighting refers to the process of calculating and assigning a weight to each word (or, in general, n-gram), reflecting its degree of importance.

Such an importance is typically bound to the term frequency, which can be declined in two different ways:

- *absolute term frequency*: the number of occurrences of the given word in a text
- *relative term frequency*: the ratio of word occurrences with respect to the some maximal value

Bag Of Words (BOW) Example

	about	bird	heard	is	the	word	you
About the bird, the bird, bird bird bird	1	5	0	0	2	0	0
You heard about the bird	1	1	1	0	1	0	1
The bird is the word	0	1	0	1	2	1	0

Word frequencies caveats

Just relying on absolute/relative word frequencies is not enough.

Given a set of documents from the same domain, some words are naturally more frequent than others (e.g., *money* in a financial domain).

Despite their higher frequency, they might not be very informative, because they are common (think of them as domain-related stop words).

TF-IDF statistic tries to cope with such an issue.

TF-IDF

Term frequency–inverse document frequency (TF-IDF) is a numerical statistic that is intended to reflect how important a word is to a document in a collection.

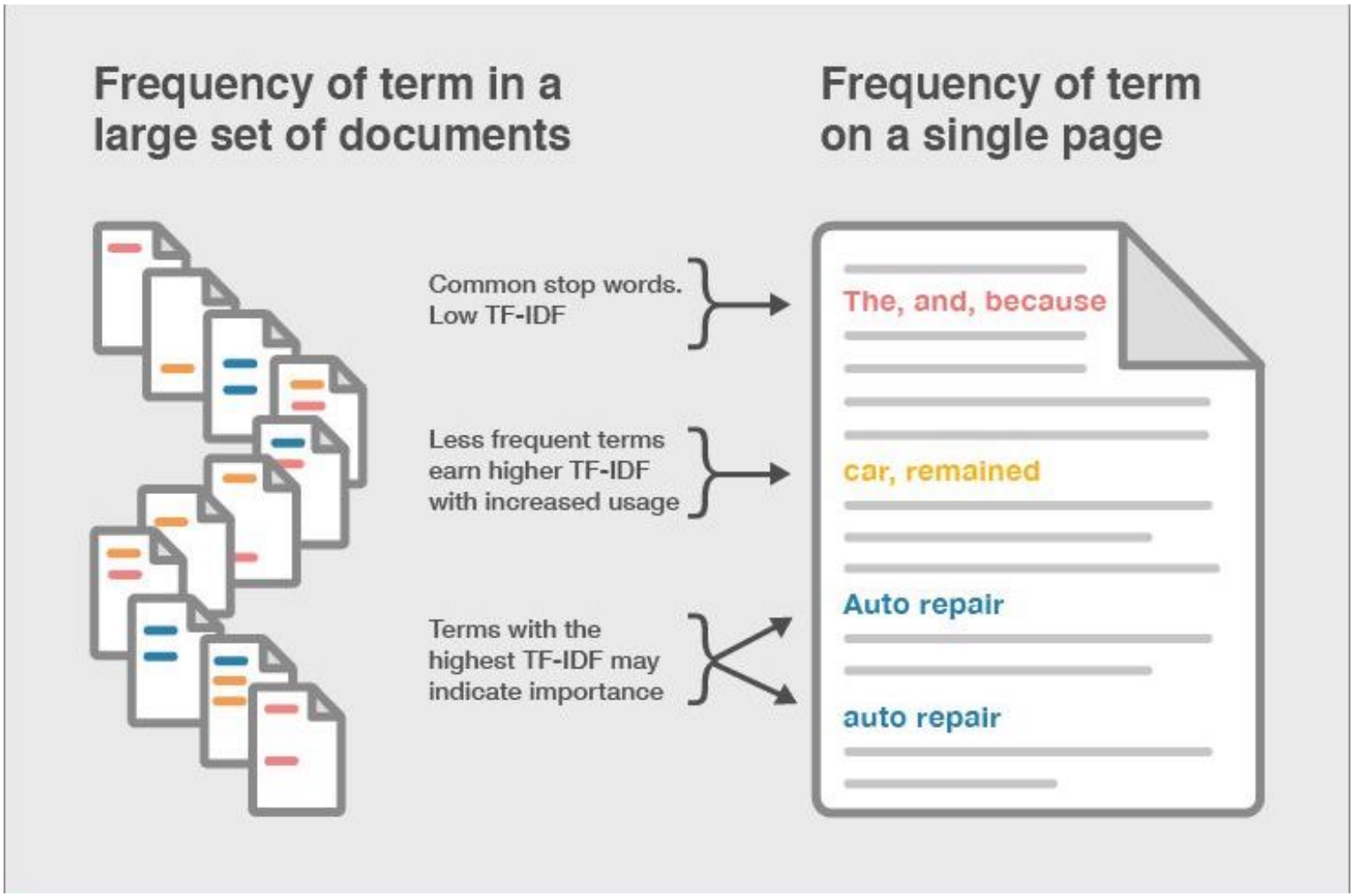
Its value increases proportionally to the number of times a word appears in the document and is offset by the number of documents in the corpus/collection that contain the word.

Given a word t in the document d, its weight W_{td} is given by:

$$W_{td} = log(\frac{N}{DF_t})TF_{td}$$

where N is the total number of documents in the collection, DF_t is the number of documents which include the word t, and TF_{td} is the number of occurrences of the word t in the document d (divided by the length of d).

TF-IDF – Example



Text Mining Tasks

Visualization

Text visualization is an essential task to perform *exploratory data analysis*, i.e., getting to know your data before delving into more complex analysis tasks.

Also, visualizing text you can intuitively, at a glance:

- understand the overall content of a document
- group documents
- compare documents

Some kinds of visualization techniques are rather intuitive (e.g., plot the histogram of word weights), some other are more complex (clouds, trees, ...).

Example text

September 10, 2009

TEXT

Obama's Health Care Speech to Congress

Following is the prepared text of President Obama's speech to Congress on the need to overhaul health care in the United States, as released by the White House.

Madame Speaker, Vice President Biden, Members of Congress, and the American people:

When I spoke here last winter, this nation was facing the worst economic crisis since the Great Depression. We wer losing an average of 700,000 jobs per month. Credit was frozen. And our financial system was on the verge of collapse.

As any American who is still looking for work or a way to pay their bills will tell you, we are by no means out of the woods. A full and vibrant recovery is many months away. And I will not let up until those Americans who seek jobs can find them; until those businesses that seek capital and credit can thrive; until all responsible homeowners can stay in their homes. That is our ultimate goal. But thanks to the bold and decisive action we have taken since January, I can stand here with confidence and say that we have pulled this economy back from the brink.

I want to thank the members of this body for your efforts and your support in these last several months, and especially those who have taken the difficult votes that have put us on a path to recovery. I also want to thank the American people for their patience and resolve during this trying time for our nation.

But we did not come here just to clean up crises. We came to build a future. So tonight, I return to speak to all of yo

Word clouds

Word clouds show the text word count in an intuitive way.

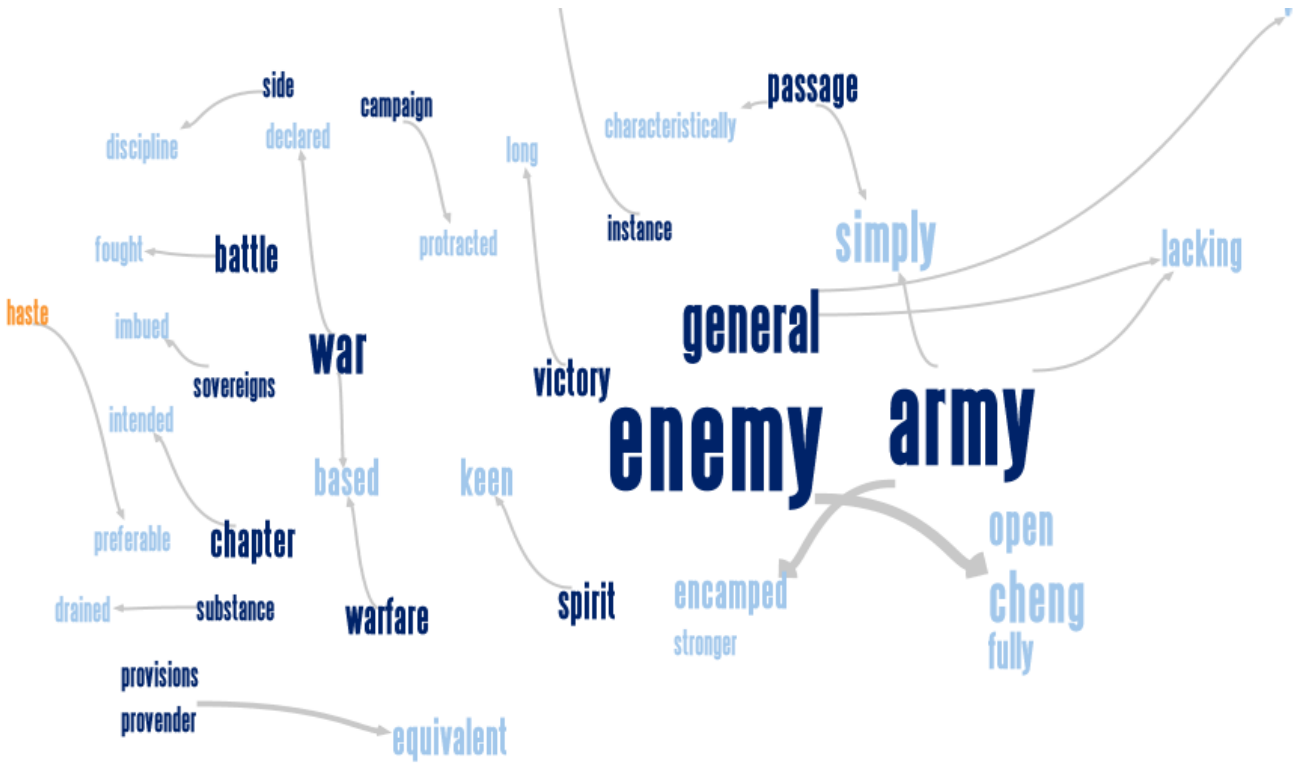
Word clouds – 2

Word trees

They show all phrases starting with a given sequence of words.

Phrase nets

It may also be interesting to consider pairs of words that are connected through some other word. For instance, this is the result of looking at words connected by the term *is* in *Sun Tzu's The Art of War*.



Classification / Regression

Classification is defined as the process of assigning one or more categories among the predefined ones to each data item.

In *regression* tasks, instead, we assign a number to each data item (the domain is continuous).

Considering text, one may want to assign a category to each document, for instance, the list of topics discussed in it; or, we may want to determine the text's overall sentiment score.

A labelled training dataset is typically needed to train suitable classification or regression models.

If such a dataset is not available, one may try to rely on clustering first.

Bibliography

Taeho Jo Text Mining Concepts, Implementation, and Big Data Challenge, Volume 45, Springer