A Simple Extraction Procedure for Bibliographical Author Field

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A procedure for bibliographic author metadata extraction from scholarly texts is presented. The author segments are identified based on capitalization and line break patterns. Two main author layout templates, which can retrieve from a varied set of title pages, are provided. Additionally, several disambiguating rules are described.

I. INTRODUCTION

Several recognition methods that target bibliographical metadata extraction from scholarly texts had been described. Based on the underlying methodological basis, they are formally grouped into two categories. One, named knowledge representation and template mining, uses prior pattern knowledge to segment texts and to retrieve data [1, 2, 3, 4, 5, 6, 7]. The other, which is based on general machine learning techniques, applies statistical devices, concretely hidden Markov models [8, 9, 10], support vector machines [11], and conditional random fields [12], to infer segmentations. The knowledge of structural patterns is thus automatically embedded into transition and conditional probability matrices that are precomputed from sample sets.

Practical implementations of these methods, not only the knowledge representation ones, but to some extend the machine learning ones, include a priori information of the textual patterns. Described patterns are font size and typeface variations, HTML markup and delimiters, relative length of title versus author segments, predefined segment ordering, and textual punctuation marks. Capitalization and line breaks, albeit being noticed in references [4, 11, 12], have eluded much of the attention and their potential has not been fully exploited.

This article focuses on the extraction of the author’s field. The presented procedure is based on the identification of simple, yet general templates or regular expressions. Author segments are recognized solely upon capitalization patterns and line break delimiters. Section II describes a minimalist text encoding or tokenization, and gives the corresponding author templates. Section III analyzes layout templates. Both author and layout templates emerge from the examination of plain text conversions of 2350 title pages. Interestingly, scholarly text layouts constrain author segments to only two main templates. This is in sharp contrast with general proper name grammars, which consist of over a hundred rules [13]. Section IV provides several disambiguating rules, and describes the use of a common name prefix lexicon that particularizes the procedure to specific domains. Section V gives the details of the data set and other implementation details.

II. TEXT ENCODING AND AUTHOR NAME TEMPLATES

Words, which are defined here as contiguous sequences of two or more letters, are mapped to a single symbol code. Different symbols are assigned based on whether all letters are uppercase, only the first letter is uppercase, or at least the first letter is lowercase. Additionally, initials, line breaks, relevant punctuation marks, and some special, high-frequency words, have a particular code. Spaces are only meaningful to discern word boundaries and are omitted in the encoded string. The complete code mapping is listed in Table I.

This encoding or tokenization, besides simplifying string matching, highlights the author patterns. The text

*Philosophia Naturalis Principia Mathematica*

*Isaac Newton*

for example, produces the encoded string [LnnnnLnnL], from which segment [nn] is identified as an author pattern. The inspection of the complete title page data set produces the following author name templates

\[ A_l = [(? : nTn|nNN|nNN|nNN|nNN|nNN|nNN|nNN|nNN)], \]

and

\[ A_u = [(? : nNN|nNN|nNN|nNN|nNN|nNN|nNN|nNN|nNN)], \]
with initial $I$ being

$$I = [I_p(0, 1)].$$  \hfill (3)

Exceptions to these patterns are one single-letter last name, and two four-word names on approximately ten thousand names. The relatively frequent cases of hyphenated names, and names with personal articles, prepositions and qualifiers, do match the patterns by simply reclassifying hyphen as being letter, and annexing personal particles in a preprocessing step. While reversed order naming is frequent in references and databases, only natural ordering appears in the title page data set.

## III. AUTHOR LAYOUT TEMPLATES

Once the text content is extracted from a document, any stylistic layout, except capitalization and line breaks, is stripped. Then emerges the bare author layout. Two layouts are found, the single block of authors

$$B_s = [LA([\text{; & L}) + \mathcal{A}) \ast (? = L)],$$  \hfill (4)



and the multiple block, with the author lines $B_a$ being followed, possibly, by the author addresses

$$\mathcal{L} = [(L[L^*)]].$$  \hfill (5)

The generic author template $\mathcal{A}$ stands for $\mathcal{A_l}$ and $\mathcal{A_a}$. The two are applied sequentially. A three-block layout, for instance, will be

$$B_3 = [(B_s)\mathcal{L}(0, 7)(B_s)\mathcal{L}(0, 7)\mathcal{L}(B_a)].$$  \hfill (6)

The set of author $\mathcal{A}$ and layout $B$ templates is sufficient to correctly extract an 83% of the authors in the data set. To extract the remaining, the patterns $[LnnL]$ and $[LnnnL]$, and the corresponding all-uppercase cases, must be disambiguated.

## IV. ADPARTICLES AND LEXICONS

Most of the $[LnnL]$ and $[LnnnL]$ patterns in the text that are not actual proper names are parts of uppercase titles spanning multiple lines. Others are publisher’s tags, such as Open Access, and a few of them are addresses. An analysis of over one hundred thousand titles has identified the most frequent words as being of, the, and, in, for, from, with, to, and on. On average, preposition of appears on any title, and on in one of every ten titles. These high-frequency words are encoded as $[a]$, and are referred here as adparticles, meaning that they are connected to, or connect other words.
Lexically, adparticles would be adpositions, adverbs, articles, conjunctions, coverbs, prepositions, or some verbal forms such as *using*. Adparticles possess, therefore, the desirable property of permitting to safely scape subsequent words. Adparticle scape templates are listed in Table II together with a case example.

Additionally, a common name lexicon has been recompiled to disambiguate cases as the previously mentioned *Open Access*, or noisy *Email Alerts*, which might appear when texts are extracted from abstract web pages. The lexicon is composed of frequent prefixes, and it is used to lowercase words before encoding the text. The prefixes are obtained according to the procedure described in Section V in order to avoid lowercasing actual proper names. Effective lexicons are domain specific, as the word frequency is. Approximately, fifty prefixes have been sufficient to correctly extract all the authors from the 2350 item data set.

### V. REMARKS

**Data Set.** Author name and layout templates have been identified based on the title page of 2350 scientific works. They include a variety of journals and publishers, in addition to self-published drafts and preprints. Most of these works have a single-block author layout. Approximately 400 works have a multi-block layout. The set is a curation from an initial set of 2600 works. Exclusion was due to either an extremely poor conversion to plain text, or due to the existence of infrequent patterns that would conflict with general templates. Disregarded patterns are single-letter last names, four-word names, lack of separator among coauthors, and line breaks between fore and last name.

**Common Name Lexicon.** To lowercase common words without conflicting with real proper names the following procedure has been devised. Given a list of author names, and a list of common word candidates, the shortest prefix of each candidate that is not an author prefix is recorded. In this way, a list of unique shortest prefixes is obtained, together with the cumulative frequency of each. The most frequent prefixes are then included in the lexicon. Note that the words *low* or *water*, even though they are frequent in chemical texts as common names, are also proper names, and, therefore, are not included. The overlap between common and proper names might be huge in an international setting. Still, frequent scientific terms, such as *functional* or *tetrahedron* appear apart from proper names.

**Additional Data and Software.** Conversions of the title pages to plain text has been accomplished using XPDF [14]. Its `pdftotext` utility has been modified, setting the rasterization parameter `maxIntraLineDelta` to 0.2 in order to eliminate possible author superscripts. Approximately one hundred thousand PubMed citations [15] has been processed to analyze title words and author names. Two lists, one with over sixty thousand unique words and their frequencies, and another with over one hundred thousand unique fore and last names, have been recompiled. These two lists have been used to build the prefix lexicon, as described above. While no more than fifty prefixes are required to correctly retrieve all the authors from the data set, for the sake of a greater generality, the lexicon has been enlarged up to 450 entries in the current implementation. The procedure for the author field extraction has been implemented in the *cb2Bib* program [16], version 1.1.1, and it is part of its set of recognition algorithms.
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