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Designing a Structured Lexicon for Document Image Analysis

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Designing a Structured Lexicon for Document Image Analysis [1]

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ABSTRACT: This paper presents a structured, multi-level architecture of a lexicon which is a central component of our knowledge-based document analysis system. Our system has the task to transform incoming business letters into an equivalent electronic representation automatically. Moreover, partial text analysis and understanding of a letter´s body and relevant parts are initiated to enrich the conceptual knowledge about the actual document (e. g., by a classification). In such an application domain, a well-designed lexicon has to consider requirements of both, text recognition and text analysis. For that purpose, we propose an appropriate lexicon architecture and the internal structure of corresponding lexical entries being a prerequisite for successful higher-level interpretations of documents.

CONTENTS:

KEYWORDS: office automation, document image analysis, structured lexicon, text recognition, text analysis, lexical knowledge.

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1 Introduction

In the last years many people have predicted the paperless office where paper documents would be obsolete. Despite all efforts in office automation, offices produce more paper than ever before. One reason for this observation is the weakness of commercial office information systems in supporting an international standard representation to facilitate the exchange of documents between heterogeneous systems. In consequence, paper documents will further remain the most popular and dominating medium for exchanging information. By this way, tools for getting existing paper documents into an equivalent symbolic representation on the computer, called paper-computer-interfaces, become increasingly important.

In this paper the lexicon component of our document analysis system is presented which is one current result of the ALV project (German acronym for Automatic Reading and Understanding). The intention of the system is to bridge the gap between traditional print products and the computer. Exemplary, the structure and semantics of German business letters are analyzed. The system is model-driven based on the ODA (Office Document Architecture) platform [ISO8613], i. e., an international standard for the representation of layout and logic structures and the exchange of documents is supported [Dengel et al92a].

In order to understand challenges and constraints in the design of an appropriate lexicon for document image analysis and to give a point of orientation, our system will be described in short (see also Figure 1). The entire system includes several interwoven phases of analysis: *Layout extraction* comprises all low-level processing routines like skew angle adjustment and segmentation to investigate the layout structure of a document. *Logical labeling* is used to hypothesize the logical meaning of layout objects. *Text recognition* explores the captured text of logical objects. By this way, word hypotheses are generated, verified and redundant word candidates are eliminated. Finally, a *partial text analysis* of selected objects (sender, subject, body) is initiated for classifying the document (invoice, order, offer, etc.) and retrieving conceptual information. As output, a symbolic representation of the actual business letter is generated that conforms to ODA. Further details and experimental results of the system are given in [Dengel89, Dengel et al92b].

This paper focusses on the presentation of a structured lexicon and corresponding access mechanisms. It is organized as follows: In the next chapter fundamental lexicon requirements are explained, set by both text recognition as well as text analysis. Note that these requirements are conflicting sometimes, i. e., a complete and best solution, a panacea, of this problem does not exist! While in Chapter 3 a multi-level architecture of our structured lexicon with respect to document analysis is developed, Chapter 4 exhibits a possible internal structure for lexical entries. Finally, the last chapter shows state of implementation and points out to our current research activities.

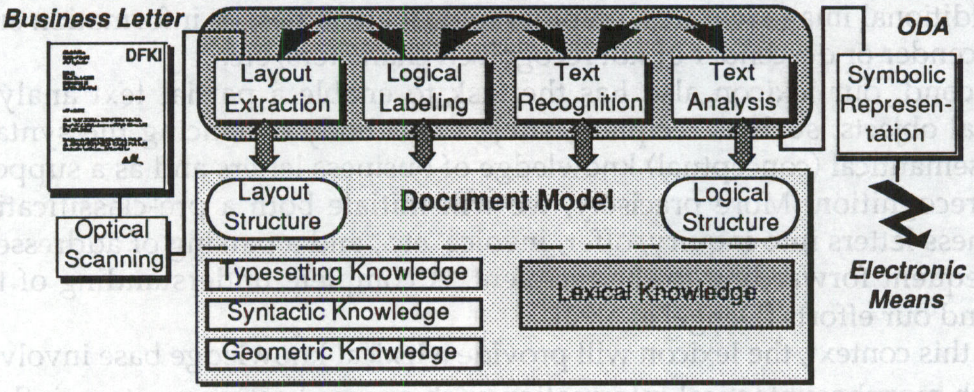

Figure 1: Global ALV-system architecture.

2 Requirements of a lexicon for document image analysis

Designing a lexicon for document image analysis is restrained to consider the requirements of two system components: text recognition and text analysis (cf. Chapter 1). These requirements are discussed in the following in more detail.

First, document analysis systems use either a lexicon (dictionary) or probabilistic methods (Markov models) to improve results of *text recognition* [Elliman90, Wells90]. Dictionary look-up techniques involve verifying an input word against legal dictionary words. In this case, structuring or partitioning the dictionary is a promising strategy for pruning the search space. However, recognition errors and incorrect character/word segmentation complicate the access and organization of a dictionary. For instance, characters are often broken or merged because of small point sizes, kerned, bold or italiced typefaces, ligatures as well as errors resulting from noise, low resolution or truncation of lines (latter is typical for faxes).

Hence, text recognition is primarily concerned with the spelling of a word form. Consequently, requirements for the lexicon include:

- compact storage allocation for storing large parts of the dictionary in main memory and for minimizing access time;
- tolerance and robustness towards recognition errors;
- in case of complete words, fast search algorithms and efficient data structures for their verification;
- in case of incomplete words, efficient pattern matching algorithms that treat queries of increasing complexity (character alternatives perhaps accompanied by certainty factors; rejection of single, non-identified characters; one or more wildcards of fixed or variable length, etc.);
- generation of appropriate word hypotheses according to incomplete input;
- dynamics: the set of words represented in the dictionary will be modified and enlarged in course of time;
- openness: an open and flexible interface which allows the specification of other knowledge sources being ascertained by image analysis, for example,

additional image features, cryptographical attributes, or information such as ascender or descender of not recognized characters, etc.

Second, our lexicon also has the task to enable a partial text analysis of logical objects, such as recipient, subject and body enhancing the syntactical and semantical (conceptual) knowledge of business letters and as a support for text recognition. More precisely, we will initiate both a pre-classification of business letters into inquiry, offer, invoice, etc., and a parsing of addresses and subsequent forwarding to the recipient. A complete understanding of text is beyond our efforts [Dengel et al92].

In this context, the lexicon will provide a lexical knowledge base involving:

- rich morphosyntactical information such as word category, stem, inflection, synonyms, homonyms, variants, usage, etc. as well as associative links to other entries (relations);
- semantical links to external, specialized dictionaries, in particularly to a thesaurus;
- a definition of logical views according to the document architecture model of ODA which reflect a structural restriction of context (e. g. employees of a company, all possible city names within an address);
- a homogeneous and coherent representation (lexical structure) which facilitates the acquisition and modification of lexical knowledge and increases the lexicon´s flexibility.

Figure 2 illustrates the central position of our lexicon in the ALV environment.

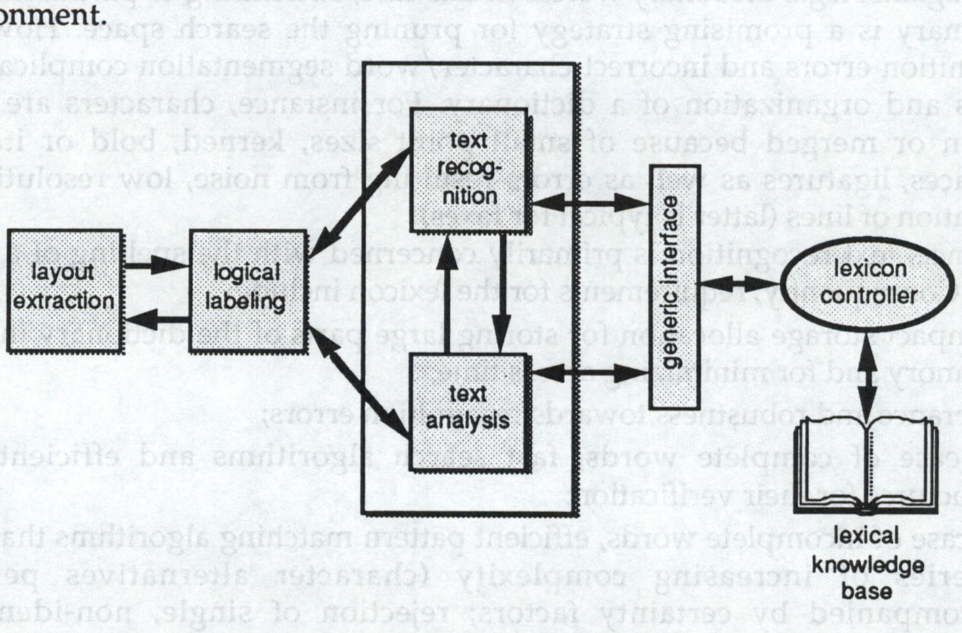

Figure 2: Phases of document image analysis and lexicon component.

3 Architecture of a structured lexicon

Having given an impression of our application domain and resulting requirements, we will now propose a multi-level architecture for a structured lexicon. Our work has been influenced by a dictionary concept shown in [Peterson80a] which is originally designed, however, to assist spelling checking and does not support a representation of lexical knowledge.

How can a lexicon be structured efficiently? A first approach to specify alternative structures is based on the frequency of word usage (see Figure 3). In the general case, a small number of words is used most frequently in documents. In German, the most frequent 500 words cover 63% of common text [Meier78]. Typically, these words have a length up to 6 characters. Because text recognition is more robust in finding short words (articles, conjunctions, adjectives, etc.) and corresponding errors only refer to one or two characters, we compiled and stored them in a separate subdictionary allowing fast access of complete words and simple error elimination. This matches the second and third requirement of text recognition in Chapter 2. Other high-frequency words are collected in a second subdictionary that is extended by an selective access matrix allowing efficient matching of fragmentary input strings (fourth and fifth requirement; see also Chapter 5) [Dengel et al92b].

In parallel, there are several domain-specific dictionaries. They include specific words or phrases which are significant for a particular application domain, actually business correspondence (e. g. "offer", "enclosed you find", "best regards", "sincerely", ...). Note that these dictionaries are pluggable: on demand they can be added or taken away for reasons of efficiency.

Furthermore, we provide logical dictionaries in accordance with logical objects of a document (cf. [ISO8613]). Logical objects divide the contents of a letter into entities associated with an sender´s intellectual meaning such as subject, address or date. Each logical dictionary represents a restriction of context accompanied by a special vocabulary and phrases (requirement three of text analysis).

Beside their (orthographical) word form, lexical entries are related to a lexical frame containing different frequency counts, simple morphological and syntactical information as well as housekeeping information (source, author, date, etc.). The detailed internal structure of entries will be described in the next chapter.

Finally, a lexicon controller supervises access of all subdictionaries, the initial loading of entries and the global organization of dictionary parts. For instance, it determines in which order input words are searched for. Right now, the scheduler implemented consults all subdictionaries sequentially. More complex and intelligent strategies have to be developed as the system evolves.

Figure 3 visualizes the architecture of our prototypical structured lexicon.

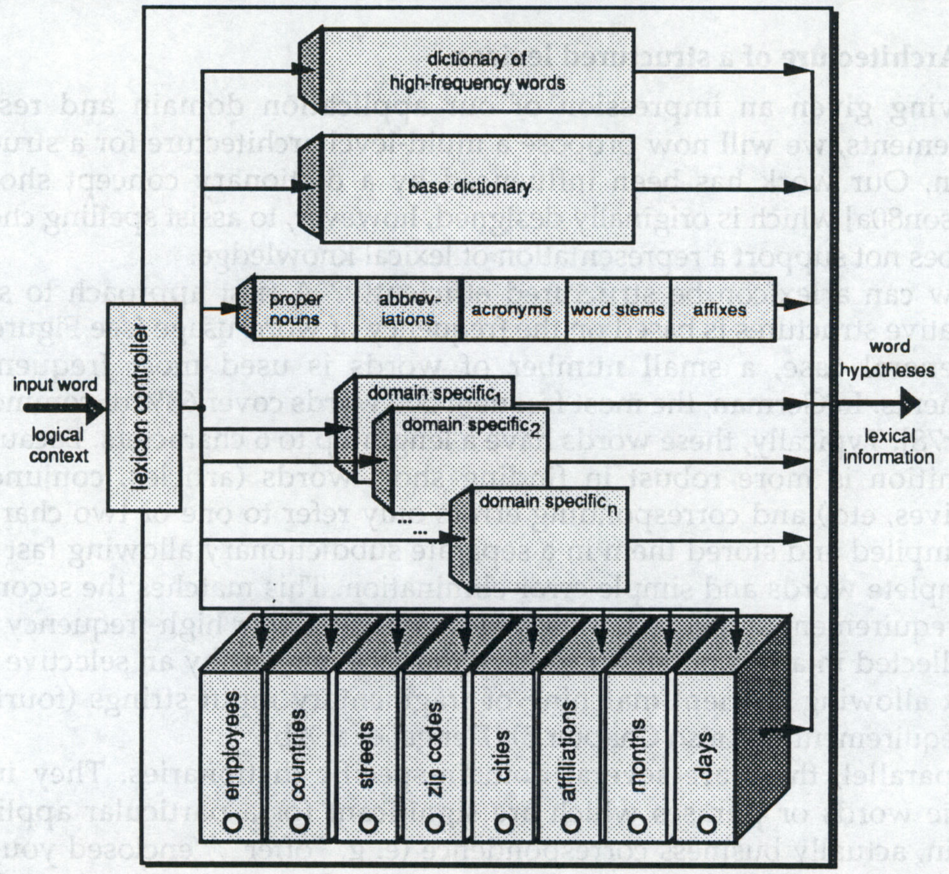

Figure 3: Multi-level architecture of lexicon.

4 Internal structure of lexicon entries

In Chapter 3 we have described the overall architecture of a structured lexicon. Now we want to examine what the elements of a lexical entry look like. By *internal structure of lexical entries* we mean the contents of one isolated entry as well as their structural setup (see also [Harris85, Bläser90]). Requirements given in Chapter 2 have to be considered in order to satisfy both system components related to the lexicon: text recognition and text analysis.

At least implicitly any dictionary presupposes a certain grammar to be known by the user. For example, it seems impossible to find the entry for German *gearbeitet* (has *worked)* without additional knowledge. In this example, one has to know that verb entries appear in infinitive form (arbeiten, to *work*), and that the past participle in German is formed with prefix *ge*- and suffix *-et*. Therefore, an electronic dictionary has to obey that grammar represented by programs using it. We are going to specify such a structure by grouping hierarchically several attributes, i. e., the lexical information concerning a lemma.

In order to support different steps of analysis, we distinguish attributes corresponding to orthography, necessary to support text recognition, and linguistic information for text analysis. Besides, it may be useful to represent some diasystematic (style, usage, ...) and statistical (frequency) information. A short description of these attributes is given now.

Attribute group *orthography* contains spelling and hyphenation of the lexical entry. For recognition, the specification of hyphenation is important to distinguish between a dash of a parenthesis and a dash in hyphenation.

Linguistic information is separated into *morphology, syntax* and *semantics,* which seems sufficient for our needs. A morphological component has close connections to the lexicon as it reduces the number of entries and primarily is used for verification of a words existence. However, a distinction between slots morphology and syntax is not easy in every case. For example, the standard categorization of words in nouns, verbs, adjectives and so on has both a morphological and a syntactical effect.

By pure morphological examination, a categorization of words starts with the distinction of inflecting and non-inflecting words. A subcategorization considers the multitude of inflectional classes, e. g. for regular and "strong" verbs. Here is an example:

```
("schreiben"   (morphology   (category    . strongVerb)
                             (addStems    (past          . "schrieb")
                                          (participle    . "geschrieben"))))
```

Information essential for a syntactic parser is summarized in the group syntax. Most important of a word is its syntactic category and subcategorizations like the gender for nouns. For a semantic representation, the underlying representation language is important. It has to provide subsumption hierarchies with (multiple) inheritance and possibilities to represent semantical links as mentioned in Chapter 2.

Finally, frequency information is helpful for all analysis components to enable a weighting of hypotheses on basis of statistical data. By this way, frequency-driven strategies may prune the search space. We add whether the frequency given concerns the word form itself or all inflectional forms of this lemma. Furthermore, the underlying statistical source or data base (text corpus) is entered.

Figure 4 gives a more detailed example of the structure of lexical entries.

```
(geschrieben  (morphology      (stem          participle2)
                               (inflection    participle2)
                               (lemma         ↑schreiben))
)
(schreibend   (morphology      (stem          participle1)
                               (inflection    participle1)
                               (lemma         ↑schreiben))
)
(schreibst    (morphology      (inflection    present 2nd singular)
                               (lemma         ↑schreiben))
)
(schriebst    (morphology      (inflection    past 2nd singular)
                               (lemma         ↑schreiben))
)
(schrieb      (morphology      (stem          past)
                               (inflection    past (1st 3rd) singular)
                               (lemma         ↑schreiben))
)
(schreib      (morphology      (stem          present)
                               (inflection    imperative singular)
                               (lemma         ↑schreiben))
)
(schreiben    (diasystematic   (style              standard)
                               (usage              no)
              )
              (frequency       (Ruoff81            84/105939)
                               (Meier67            93/10910777)
              )
              (morphology      (category           strongVerb)
                               (inflection         infinitive
                                                   (present (1st 3rd) plural))
                               (verbType           3)
                               (past               schrieb)
                               (participle         geschrieben)
              )
              (syntax          (category           fullVerb)
                               (perfectAux         haben)
                               (attrParticiple     T)
                               (passive            (auxiliary   (werden sein)))
                               (active             (valency     42)))
)
```

Figure 4: Structure of lexicon entries.

5 State of implementation and current activities

A first prototype of our structured lexicon has been implemented on Sun SPARCstations in Common Lisp/CLOS. We have also connected the lexicon with one of our text recognition specialists (based on feature extraction of characters) improving its results dramatically [Dengel et al92b].

At moment, the lexicon comprises a basis of 500 high-frequency German word forms that are stored separately in a specialized hash table allowing fast access of words and rudimentary error elimination. Additionally, our base dictionary contains further 8500 words collected in a trie data structure. This trie is extended by an selective access matrix for incomplete input and provides efficient search heuristics [Dengel et al92b, Knuth73].

All lexicon entries are enhanced by frequency counts of different text corpora and simple morphosyntactical information gained from a morphological tool for German [Finkler86, Finkler88]. Note that frequency counts and word statistics are used for a pre-classification of business letters applying traditional techniques of information retrieval [Dittrich92]. Furthermore, word stems and affixes are represented in the lexicon, too [Wagner92].

Our current research activities are concentrated on the following four topics:

A generic interface for utilizing additional results of text recognition (beyond ASCII level) is under development. First, it will allow the treatment of word hypotheses networks with probabilities for each character including wildcards for unrecognized ones. Second, this interface also deals with the coding of outcomes from an alternative cryptographical text recognition.

The lexicon controller introduced in Chapter 3 will be enhanced by intelligent control strategies, e. g., to take advantage of logical views. Such techniques are thought for pruning search space in a larger lexicon.

To enable a flexible (re-)structuring of the architecture developed in Chapter 4, we would prefer a lexical database with a user-interface for acquisition and maintenance. During start-up of the system, it should be compiled into an internal representation. Thereby an expansion of lexical templates, as used in natural language processing, should be performed.

Finally, a full integration of text analysis into the existing system is striven for. Especially, a broader usage of morphosyntactical information in supporting text recognition is enforced. For that goal, it is necessary to enhance the internal structure of lexical entries with more linguistic knowledge.

References

[Bläser90] B. Bläser, M. Wermke. Projekt "Elektronische Wörterbücher/Lexika": Abschlußbericht der Definitionsphase. *IBM IWBS Report 145*, Heidelberg, November 1990.

[Dengel&Barth89] A. Dengel, G. Barth. ANASTASIL: Hybrid Knowledge-based System for Document Image Analysis. *Proc. of the IJCAI´89*, vol. 2, Detroit, MI, 1989, pp. 1249-1254.

[Dengel et al92a] A. Dengel, R. Bleisinger, R. Hoch, F. Fein, F. Hönes. From Paper to an Office Document Standard Representation. *IEEE Computer*, special issue on document image analysis, 1992 (to appear).

[Dengel et al92b] A. Dengel, A. Pleyer, R. Hoch. Fragmentary String Matching by Selective Access to Hybrid Tries. Submitted to: *11th International Conference on Pattern Recognition*, The Hague, Aug./Sept., 1992.

[Dittrich92] Stefan Dittrich. *Automatische, Dekriptor-basierte Unterstützung der Dokumentanalyse zur Fokussierung und Klassifizierung von Geschäftsbriefen*. Diploma Thesis, Department of Computer Science, University of Kaiserslautern, May 1992 (in German).

[Elliman90] D. G. Elliman, I. T. Lancaster. A review of segmentation and contextual analysis techniques for text recognition. *Pattern Recognition*, vol. 23, no. 3/4 , 1990, pp. 337-346.

[Finkler86] W. Finkler, G. Neumann. *MORPHIX – Ein hochportabler Lemmatisierungsmodul für das Deutsche*. Universität des Saarlandes (SFB 314), Memo Nr. 8, Saarbrücken, 1986 (in German).

[Finkler88] W. Finkler, G. Neumann. MORPHIX – A Fast Realization of a Classification-Based Approach to Morphology. *Proceedings of 4th Österreichische Artificial-Intelligence-Tagung*; Springer Verlag, Berlin 1988; pp. 11-19.

[Harris85] M. D. Harris. *Introduction to Natural Language Processing*. Reston Publishing Company Inc., Reston, Virginia, 1985.

[ISO8613] ISO 8613 Information Processing, Text and Office Systems. *Office Document Architecture and Interchange Format (ODA/ODIF)*, parts 1-8, 1988.

[Knuth73] D. E. Knuth. *The Art of Computer Programming. vol. III: Sorting and Searching*. Addison-Wesley, Reading, Mass., 1973.

[Meier78] Helmut Meier. *Deutsche Sprachstatistik.*. Georg Olms Verlag, Hildesheim, 2. erweiterte und verbesserte Auflage, Paperback, Band 31, 1978 (in German).

[Peterson80a] J. L. Peterson. Computer Programs for Detecting and Correcting Spelling Errors. *Communications of the ACM*, vol. 23, no. 12, December 1980, pp. 676-687.

[Wagner92] Andreas Wagner. *Organisation und Zugriffsstrukturen eines Lexikons zur Dokumentanalyse — Ein hashbasierter Ansatz*. Diploma Thesis, Department of Computer Science, University of Kaiserslautern, June 1992 (in German).

[Wells90] C. J. Wells et al. Fast Dictionary Look-Up For Contextual Word Recognition. *Pattern Recognition*, vol. 23, no. 5, 1990, pp. 501-508.

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