

Summary of the Activities of the Istituto di Linguistica Computazionale

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Abstract: This article summarizes the activities of the Istituto di Linguistica Computazionale. We discuss the Italian Multifunctional Lexical Databases; the projects focussing on linguistic analysis and generation; corpora in the MRF, textual databases and linguistic workstations; computer-assisted humanities teaching; and the various cooperative ventures, seminars and conferences offered by the Institute.

Key Words: Istituto di Linguistica Computazionale, CNR, computational linguistics, databases, linguistic analysis, parsing.

The Linguistic Division of CNUCE, founded by A. Zampolli in 1968, has been transformed, in 1978, into the Institute of Computational Linguistics (ICL) of the National Research Council (CNR).

The ICL inherited the traditional activities of the Linguistics Division (described for example in Zampolli, 1973b, 1973c), with an increasing stress on research aspects. The Humanities Committee of the CNR assigned to the Institute the goals of promoting and assisting research, and coordinat-

ing international relationships in the field of computational linguistics in Italy.¹

Owing to space constraints, the activities of our institute will be summarized in the following pages.²

Italian Multifunctional Lexical Databases (IMLDB)

The lexical material of the Italian Machine Dictionary³ is now reorganized in the form of a lexical database (LDB), that is, a large repository of lexical data where lexical units (morphemes, lemmas, forms, etc.) are stored together with many kinds of lexical properties⁴ and lexical relations,⁵ and where access is provided at the various levels of lexical units, properties and relations. The LDB is conceived as multifunctional with respect to the data, the applications, and the different linguistic theories. At present, the activities concentrate on:

Extension of the lexical (sub)set in the IMLDB; completion of the linguistic information according to a polytheoretical model

We have promoted an international working group⁶ to assess the feasibility of constructing such a "polytheoretical lexicon," in which different linguistic schools (GB, LFG, MPSG, GPSG, categorial and systemic grammar), computational linguistics approaches and lexicographic practices are represented (Walker, Zampolli, Calzolari, 1987).

Reusability of lexicographic information

Monolingual and bilingual dictionaries today are very often printed in photocomposition, and hence recorded in MRF. Various Institutes are

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exploring the reusability of the information explicitly or implicitly present in machine-readable dictionaries. Our efforts are mainly concentrated on two areas: the semiautomatic extraction of semantic relations of various kinds (about a hundred) from the definitions of monolingual dictionaries: and the reuse of the information supplied by bilingual dictionaries (see below).

The Italian MLDB in a multilingual environment

We conceive a bilingual MLDB as a complex structure consisting, essentially, of the following components:

- (i) A MLDB for the first language (L1) structured according to the aforementioned principles.
- (ii) A MLDB for the second language (L2), structured according to the same or similar principles.
- (iii) A bilingual "bridge" connecting the two monolingual MLDBs, that is a set of relations and conditions connecting their elements.
- (iv) A textual database containing, along with a reference corpus for L1 and L2, a set of (so-called) "contrasted bilingual texts." By this expression we mean a structure including a text in one language, its translation into another, plus a set of cross-references explicitly indicating the relations of (translational) equivalence between the corresponding elements of the two texts.
- (v) A set of procedures and software tools for access to the data, both for programs and human users, which will allow the retrieval operations to start from every pertinent point in the entire structure.

In our opinion, a bilingual MLDB must be considered as several things. First, it is a source of data for contrastive and comparative linguistic studies. Second, it can be a component in a workstation for assistance in translation. Third, it provides a source of information for the construction of lexical components of natural language processing systems which require some type of transfer between languages, or the searching, in contrastive corpora, of possible translational equivalents for bilingual lexicography. Finally, it can be used as a tool for computer-assisted language and acquisition.

Linguistic Analysis and Generation

The automatic recognition and representation of linguistic units of various levels occurring in running texts is a fundamental phase for text-processing procedures in various humanistic research fields as well as for theoretical studies of linguistic, psycholinguistic, and computational models of natural language processing. The activities of our Institute are motivated by such considerations and by the participation in European projects and cooperation with European and American industries.

Obviously, the IMLDB has to supply the relevant lexical information to our analysis and generation components.

Phonology

Our systems, using phonetic information recorded in the IMLDB, perform the phonological transcription of written texts, their subdivision into syllables, the calculus of combinatorial phenomena, etc.

Morphological analysis and semi-automatic lemmatization for Italian, Spanish, and Latin

Systems for semi-automatic lemmatization have been constructed at the ILC for Italian, Spanish, and Latin and are being progressively refined. The Spanish system includes some 7,000 stems taken from the Juilland-Rodriguez frequency dictionary. The Latin system includes approximately 50,000 stems taken from the Oxford Latin Dictionary. Its morphological component is capable of dealing with all the variants of Latin morphology from the 4th century B.C. to the 4th century A.D. Both systems work through the decomposition of the word to be lemmatized: (prefix), stem, (affix), (suffixes), ending, (enclitics). The Italian system is based on the lexical information available in the IMLDB.

For Latin the homographs are submitted to the lemmatizer who manually distinguishes the "meanings" of the various occurrences. For Spanish, a contextual analyzer tries to solve the homographies between forms belonging to different parts of speech, using co-occurrence restrictions: the success rate is more than 95%. For Italian an analogous system for disambiguating homographs is being developed.

Knowledge representation system

A knowledge representation language (KL-Magma) was implemented, based on Structured Inheritance Networks (SI-Nets), similar to KL-ONE. The language is supplied with an automatic classification system which makes it possible to place an object within the knowledge net on the basis of the description provided by the user.

KL-Magma is used for applications such as: the creation of an automatic system for the teaching of elementary geometry; the definition of a knowledge base for an expert system in the field of radiation protection; and various applications within the field of natural language processing (use of quantifiers, lexical description on a cognitive base, etc.).

A new language of knowledge representation is also in the experimental stage. It is still based on SI-Nets, but is not structure-oriented like KL-Magma. The functions of this language simulate conceptual operations underlying the communicative use of natural language.

Parsing, interfaces and dialogue

This research has followed three main trends: parsing techniques, interfaces to knowledge bases, and computational models of dialogue.

In the area of parsing, various methodologies and implementation issues have been addressed: treatment of context-sensitive phenomena; overcoming constraints of ATN stack memory; design of a bottom-up parser capable of running Augmented Phrase Structure Grammars, Categorical Grammars, Semantic Grammars, parallel semantic interpretation, Prolog parsing with Definite Clause Grammar and Extraposition Grammar for Italian, etc.

In the domain of interfaces two different applications have been designed according to the different types of knowledge conveyed by natural language.

In general, descriptive texts such as technical manuals express definitory knowledge (often referred to as terminological knowledge) which can be suitably represented in KLONE-like knowledge representation language. A semantic interpreter has been designed and implemented which maps functional descriptions of sentences taken from technical texts onto KL-MAGMA structures

representing definitional knowledge about the entities referred to in the sentences. The system uses a case frame representation of verbs grouped in verbs-types, contextually instantiated.

The construction of assertional knowledge is, instead, addressed by SAIL, a system which maps assertions concerning a specific geographic environment onto structures expressed in MRS, a knowledge representation language based on 1st order logic. The system builds a knowledge base starting from sentences expressed in natural language, answers questions and gives advice concerning the described environment.

Finally, in the domain of dialogue modelling, studies are being carried out, in cooperation with the Department of Linguistics within the framework of an ESPRIT and PROMETHEUS project, aiming at the construction of a computational model of verbal as well as non-verbal communication.

Corpora in MRF, Textual Databases, Linguistic Workstations*Literary and linguistic text processing*

From the very beginning we have tried to design a generalized encoding system, aimed at representing the variety of graphemic information which may be encountered in texts of different ancient and modern languages.⁷ Generalized procedures have been created aimed at producing the variety of results (indices, concordances, quantitative data, etc.) typically required by different disciplinary areas: classical and modern literature and philology, stylistic and statistic studies, psycholinguistic research, historical linguistics, lexicology and lexicography, historical analysis of textual sources, etc. At present, it appears that text processing procedures are becoming routine tools in scholarly practice. We continue assisting Italian and foreign projects to occasionally enrich our systems with new functions, if required by specific needs.⁸

Textual databases and linguistic workstations

Our main interest now focuses on interactive multifunctional textual databases accessible through specialized workstations. In order to increase the potential uses of our textual material⁹ and bearing in mind the availability of increasing

computing power and storage facilities on a local base (PCs, WORM, CD-ROM, etc.), we are transforming our archives into linguistic databases, that is, a set of linguistic data of different types, aimed at interactive utilization by multiple categories of potential users, associated to specialized software modules for access, interrogation and on-line processing.

Some examples of the functions of our interactive system are:

- (i) to efficiently compact texts and their analyses on various kinds of magnetic and optical memories, in particular connected to PCs;
- (ii) to retrieve textual elements flexibly defined by the user: continuous or discontinuous strings, words or parts of words, word co-occurrences or patterns, members of recursively defined "families" of words, etc.;
- (iii) to "expand" the questions of the users through the lexical knowledge embedded in the MLDB: for examples, to search for a lexical unit, all the inflected forms the synonyms, hyponyms, members of the same semantic fields and, in general, words connected by the semantic relations represented in the MLDB.

Computer-assisted Humanities Teaching

Also owing to a governmental decision, various kinds of computers are introduced in various orders of Italian schools. Unlike "hard science" teachers, humanities teachers are still imagining and preparing the use of computers for teaching purposes. Quite a few of them have recourse to the ILC. In response to their requests, we are examining ways in which our materials and procedures can be adapted to their needs. Experiments are envisaged for foreign language teaching (particularly reusing parsers, grammars, monolingual and bilingual lexical databases and for literary exercises (reusing corpora and textual databases etc.).

International Cooperation, Meetings and Summer Schools

The ILC is the venue of the national strategic projects "natural language processing" and "linguistic tools for language industries." It also participates in the strategic projects "Artificial Intelligence" and "Man-machine Communication," in

the European Projects ESPRIT, EUROTRA, PROMETEUS, and cooperates with several industries. The director and other members of the Institute are active in the Committee of International Scientific Associations (ALLC, AILA, ACL, EURALEX, FID/LD, etc.). Cooperative ventures are underway with several universities (Heidelberg, Cambridge, Oxford, Liège, Sofia, Prague, Vancouver, Princeton, Stanford, MIT, Saarbrücken, Paris, Cardiff, etc.) and research organizations (Academy of Sciences of Czechoslovakia, Bulgaria, INALF of CNRS, Max Planck Institute of Göttingen, etc.).

The ILC regularly organizes seminars and conferences within its field of activity.¹⁰ In cooperation with Pisa University, it also organizes a series of International Summer Schools on Mathematical and Computational Linguistics.¹¹

Notes

¹ It is well known that, in particular in the USA, "computational linguistics" and "literary and linguistic computing" are often considered as two separate fields (Karlgrén and Zampolli, in Zampolli and Calzolari, 1977) with practically no scientific and organizational interconnections. On the contrary, we considered that they are two aspects of the same field, having in common several methodological issues. For example, they require similar components: machine dictionaries, textual database management systems, parsers, etc.

² For a more detailed account, see Zampolli, 1983b.

³ Zampolli (1968) suggested the creation of a multifunctional Italian Machine Dictionary (DMI) which was to meet the following objectives:

- (i) to allow the semi-automatic lemmatization and automatic phonological transcription of contemporary Italian texts;
- (ii) to provide the necessary lexical information to parsers and generators of Italian sentences;
- (iii) to constitute a computational representation of the Italian lexical system, allowing a number of studies and researches on its quantitative and qualitative structures.

In its first version, the DMI was composed of a list of approximately 106,000 lemmas, obtained by comparing the major Italian dictionaries. About 1,000,000 word-forms were automatically generated by a flexional algorithm, which operated on morphological codes, semi-automatically associated to each lemma, analyzing its ending (Ferrari, 1973).

At a later stage, about 186,000 definitions were added in machine-readable form.

⁴ At phonological, morphological, lexical, syntactical, semantic, stylistic, frequency levels.

⁵ For example: synonyms, antonyms, hyperonyms, derivations, part-of, said-of, etc. In all, more than 100 types of relations are envisaged. Semi-automatic procedures are used to extract the relations from the analysis of definitions (Calzolari, forthcoming).

⁶ At present, the group includes research of universities (Princeton, MIT, Stanford, Cambridge, Heidelberg, Cardiff, Pisa), industries (Bell C.L.), and publishing houses (Collins).

⁷ See the articles of the users in the first issue of *Linguistica Computazionale* (1981), and Zampolli-Brogna (1979).

⁸ For example we are preparing, in cooperation with the Bulgarian Academy of Sciences, components for the treatment of the critical apparatus in the production of indices and concordances (Bozzi et alii, 1986). We are studying and implementing, in strict cooperation with the CHILDES database methodologies for the representation in machine-readable form of transcripts of children interviews. We cooperate with the NADIR projects (cf. Sobrero et alii) for the representation and processing of dialectal and regional data of various kinds: questionnaires, free conversational samples, video recordings, etc.

⁹ In cooperation with the users of our text processing methodologies (more than 100 Italian and foreign universities), a large number of texts (about 50,000 million words in 32 languages) have been recorded in machine-readable form. Other corpora have been obtained from specialized centres of various countries, or are accessible through bilateral agreements (Thesaurus Linguae Graecae, Oxford Archive, Trésor de la Langue Française, Sprakdata, etc.).

¹⁰ Among the meetings organized in Pisa (in cooperation with the Chair of Computational Linguistics of the University), we can mention:

- International Symposium "Lexicon electronicum latinum," 1968;
- Colloque international sur l'élaboration électronique en lexicologie et lexicographie, 1970 (Zampolli, 1973a);
- COLING 73: Vth International Conference on Computational Linguistics, 1973 (Zampolli and Calzolari 1977, 1980);
- European Science Foundation Workshop on "The Possibilities and Limits of the Computer in producing and publishing Dictionaries," 1981 (Zampolli and Cappelli, 1983);
- Round Table on "Ordenadores y Lengua Espanola," 1981 (Catarsi et al., 1982);
- Round Table on "Knowledge Representation in Italy," 1981 (Cappelli, 1983);
- "Computers in Literary and Linguistic Research," VIIth International Symposium of the ALLC, 1982 (Cignoni and Peters, 1983);
- Conference and Inaugural Meeting of the European Chapter of the Association for Computational Linguistics, 1983;
- International Workshop "Automating the Lexicon," sponsored by EEC, ACL, ALLC, AILA, EURALEX, 1986;
- International Workshop "A Common European Doctorate in Computational Linguistics" sponsored by the Council of Europe, 1987;
- International Round Table "Polytheoretical Lexicon," 1987 (Walker, Zampolli and Calzolari, 1987).

¹¹ The following have been held:

- 1970 — Introduction to Computational and Statistical Linguistics (Zampolli, 1973a)
- 1972 — Lexicology, Lexicography and Electronic Data Processing (various articles in *Cahiers de Lexicologie*, Nos. 38—40

1974 — Natural Language Understanding (Zampolli, 1977a)

1977 — Syntax, Semantics and Computational Linguistics

1988 — Computational Lexicology and Lexicography (organized for the European Science Foundation).

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