

1998 IRCS TECHNICAL REPORT ABSTRACTS

A Formalism for Resource-Oriented Planning

Giorgi Japaridze
IRCS-98-01

We introduce a formalism and a semantics for resource-oriented planning. The advantage of resource-based planning over the traditional approaches to planning is that it avoids the frame problem. Our approach can also handle many aspects of the knowledge preconditions problem without a need to introduce epistemic operators.

The logic induced by our semantics is a version of linear logic but in a much more expressive language, which contains the languages of linear logic and classical logic as sublanguages. Our semantics can be viewed as a materialization of the resource philosophy traditionally associated with linear logic and other substructural logics.

Information Structure and the Syntax-Phonology Interface

Mark Steedman
IRCS-98-02

This paper proposes a theory relating syntax, semantics, and intonational prosody, and covering a wide range of English intonational tunes and their semantic interpretation in terms of focus and information structure. The theory is based on a version of combinatory categorial grammar which directly pairs phonological and logical forms without intermediary representational levels.

An Image-based Framework for Global Illumination in Animated Environments (Ph.D. Dissertation)

Jeffrey S. Nimeroff
IRCS-98-03

Interacting with environments exhibiting the subtle lighting effects found in the real world gives designers a better understanding of the scene's structure by providing rich visual cues. The major hurdle is that global illumination algorithms are too inefficient to quickly compute their solutions for reasonably sized environments. When motion is allowed within the environment, the problem becomes even more intractable. We address the problem of sampling and reconstructing an environment's time-varying radiance distribution, its spatio-temporal global illumination information, allowing the efficient generation of arbitrary views of the environment at arbitrary points in time. The radiance distribution formalizes incoming chromatic radiance at all points within a constrained view space, along all directions, at all times. Since these distributions cannot, in general, be calculated analytically, we introduce a framework for specifying and computing sample values from the distribution and progress through a series of sample-based approximations designed to allow easy and accurate reconstruction of images extracted from the distribution. The first approximation is based on storing time-sequences of images at strategic locations within the chosen view space. An

image of the environment is constructed by first blending the images contained in the individual time-sequences to get the desired time and then using view interpolation to merge the proximate views. The results presented here demonstrate the feasibility and utility of the method but also show its major drawback. An inability to accurately model the temporal radiance variations using image sequences without resorting to a high sampling rate leads to the replacement of the image sequences by a sparse temporal image volume representation for storing randomly, or adaptively, placed radiance samples. Triangulation techniques are then used to reconstruct the radiance distribution at the desired time from a proximate set of stored spatio-temporal radiance samples. The results presented here show that temporal image volumes allow for more accurate and efficient temporal reconstruction requiring less sampling than the more traditional time-sequence approach.

An Architecture for Behavioral Locomotion (Ph.D. Dissertation)

Barry D. Reich
IRCS-98-04

We present a complete architecture for behavioral control of locomotion for both real and simulated agents and provide a design methodology for building the locomotion control systems that embody the architecture. A low-level locomotion engine controls an agent's actions directly based on intermediate-level reactive behaviors such as attraction and avoidance. High-level state machines schedule and control the reactive behaviors allowing for more "intelligent" decision processes, and an agent model provides a mechanism for varying locomotion according to agent state and personality attributes.

In addition to providing specifications for a locomotion engine, we address the problem of selecting and organizing an appropriate set of behaviors. We present selection criteria and a method for partitioning the behaviors to aid in implementation. We discuss the challenges specific to human locomotion and explain how to overcome them in the system design process. Finally, we introduce the notion of anticipation to the field of behavioral control and use it extensively throughout the system to produce agents whose actions are more realistic.

Models of Co-occurrence

I. Dan Melamed
IRCS-98-05

A **model of co-occurrence** in bitext is a boolean predicate that indicates whether a given pair of word *tokens* co-occur in corresponding regions of the bitext space. Co-occurrence is a precondition for the possibility that two tokens might be mutual translations. Models of co-occurrence are the glue that binds methods for mapping bitext correspondence with methods for estimating translation models into an integrated

system for exploiting parallel texts. Different models of co-occurrence are possible, depending on the kind of bitext map that is available, the language-specific information that is available, and the assumptions made about the nature of translational equivalence. Although most statistical translation models are based on models of co-occurrence, modeling co-occurrence correctly is more difficult than it may at first appear.

Annotation Style Guide for the Blinker Project
I. Dan Melamed
IRCS-98-06

This annotation style guide was created by and for the Blinker project at the University of Pennsylvania. The Blinker project was so named after the “bilingual linker” GUI, which was created to enable bilingual annotators to “link” word tokens that are mutual translations in parallel texts.

Manual Annotation of Translational Equivalence: The Blinker Project
I. Dan Melamed
IRCS-98-07

Bilingual annotators were paid to link roughly sixteen thousand corresponding words between on-line versions of the Bible in modern French and modern English. These annotations are freely available to the research community from <http://www.cis.upenn.edu/~melamed>. The annotations can be used for several purposes. First, they can be used as a standard data set for developing and testing translation lexicons and statistical translation models. Second, researchers in lexical semantics will be able to mine the annotations for insights about cross-linguistic lexicalization patterns. Third, the annotations can be used in research into certain recently proposed methods for monolingual word-sense disambiguation. This paper describes the annotated texts, the specially-designed annotation tool, and the strategies employed to increase the consistency of the annotations. The annotation process was repeated five times by different annotators. Inter-annotator agreement rates indicate that the annotations are reasonably reliable and that the method is easy to replicate.

Word-to-Word Models of Translational Equivalence
I. Dan Melamed
IRCS-98-08

Parallel texts (bitexts) have properties that distinguish them from other kinds of parallel data. First, most words translate to only one other word. Second, bitext correspondence is noisy. This article presents methods for biasing statistical translation models to reflect these properties. Analysis of the expected behavior of these biases in the presence of sparse data predicts that they will result in more accurate models. The prediction is confirmed by evaluation with respect to a gold standard --- translation models that are biased in

this fashion are significantly more accurate than a baseline knowledge-poor model. This article also shows how a statistical translation model can take advantage of various kinds of pre-existing knowledge that might be available about particular language pairs. Even the simplest kinds of language-specific knowledge, such as the distinction between content words and function words, is shown to reliably boost translation model performance on some tasks. Statistical translation models that are informed by pre-existing knowledge about the model domain combine the best of both the rationalist and empiricist traditions.

Pronunciation Modeling in Speech Synthesis (Ph.D Dissertation)
Corey Miller
IRCS-98-09

This dissertation investigates the area of pronunciation modeling in speech synthesis. By pronunciation modeling, we mean architectures and principles for generating high-quality human-like pronunciations. The term pronunciation modeling has previously been applied in the context of speech recognition (e.g. Byrne et al. 1997). In that context, it describes theories and procedures for handling the pronunciation variation that naturally occurs across speakers. In contrast, our work is in the domain of text-to-speech synthesis, which, as we will show, requires modeling the pronunciation variation of an individual whose speech the synthesizer is attempting to model. We will explain our methodology for learning and reproducing pronunciation variation on an individual basis, and show how most crucial features of such variation can be easily generated using the architecture we describe. Throughout the course of this exposition, we highlight contributions to linguistic theory that such a thorough analysis of individual variation provides. We describe the postlexical module of an English text-to-speech synthesizer. This module is responsible for transforming underlying lexical pronunciations from a lexical database into contextually appropriate surface postlexical pronunciations. This transformation is achieved by machine learning of a corpus of hand-labeled postlexical pronunciations that have been aligned with lexical pronunciations. The machine learning is conducted by a neural network, whose architecture and data encoding we describe. A thorough analysis of the performance of the postlexical module is offered, with attention to the relative success of the neural network at learning a wide range of postlexical phenomena. We examine the extent to which a symbolic approach to allophony is warranted, and provide an acoustic analysis that attempts to provide an answer to this question. Assessments of the success of currently existing theories of phonetics, phonology and their interface are offered, based on the experience of generating a complete postlexical phonology of English for use in synthetic speech.

**Determining Determiner Sequencing:
A Syntactical Analysis for English
B. A. Hockey and Heather Mateyak
IRCS-98-10**

Most work on determiners has been concerned with purely semantic properties, the occurrence of particular determiners in certain syntactic environments such as existential-there sentences, determiners as heads of phrases (the DP hypothesis, Abney 1987) or quantifier scoping. One question that has not been extensively discussed in the literature is how the various English determiners order with respect to each other.

This paper presents a syntactic account of determiner sequencing using a set of nine semantically based features. Each determiner carries with it a set of feature values that represent its properties, and a set of values for the properties of any determiners it may modify. These features also play a crucial role in deciding which determiners can participate in constructions such as the number system, genitives, and partitives, as well as which determiners can be modified by adverbs. This analysis of determiner ordering was developed as part of the XTAG project and is presented within the framework of Feature-Based Tree Adjoining Grammar.

**Information Extraction and Object Views
Zoé Lacroix
IRCS-98-11**

Information extraction consists in identifying classes of events and relationships between extracted instances of these classes. In general, extracted data usually fills slots in a template and is stored in tables. We propose to extend the usual approach to the use of an object database. Information extraction tools have a conceptual representation as schema components: concept classes, meta-concepts and attributes. The user expresses in his query a structure (target structure) which corresponds to his understanding of the domain and is used as a schema for the database. We use the object data model whose syntax matches both the user's target structure and the conceptual representation of extracting capabilities. Query evaluation consists in first determining the schema of the database as expressed by the user, and secondly populating the database through methods invoking extraction tools on a given source of documents. In a third step, it returns the output of the query against the resulting database. The two first steps define an object view of the given source(s) as a materialized extension of the current schema (each refinement of a query may add more structure, and thus more extracted data) followed by a non-materialized projection.

Our approach is user-oriented: the object representation of data provides the user with the flexibility of asking his query with his understanding of the domain, and object views are built on-the-fly according to the user's organization of data. The modularity of the conceptual representation of extraction

capabilities in a pool of schema components enables easy plug-in of new extracting tools.

**Fourth International Workshop on Tree Adjoining
Grammars and Related Formalisms (TAG+4)
IRCS-98-12**

**Burglars, Babysitters and Persons: A Sociolinguistic Study
of Pronouns in Philadelphia and Minneapolis (Ph.D.
Dissertation)
Lou Ann Matossian
IRCS-98-13**

To the feminists of the nineteenth and early twentieth centuries, in their quest for legal personhood, belongs the credit for identifying language as both instrument and mirror of women's social status. Following a review of language as an issue in the U.S. woman suffrage movement, the present study documents contemporary generic pronouns in colloquial Euro-American usage. More than 1200 tokens were collected in four urban neighborhoods (Elmwood/Southwest and West Mount Airy in Philadelphia and Beltrami and Fuller in Minneapolis) by means of oral-history interviews and written questionnaires on topics of local interest. The settlement history and social networks of these four communities are presented. Statistical analysis shows that *he* was seldom used for epicene referents and appeared only about half the time even for masculine-generic referents. Indeed, the predominance of singular *they* and the near-absence of *she*, even for feminine-generic referents, appeared to be *faits accomplis* in colloquial usage. In contrast to the overtly gendered pronouns, the referential nonsolidity of singular *they* was conducive to pronoun switching and also explained why *they* was preferred for generic use even when the referent was female. Female language-users tended to avoid epicene *he*, and their use of singular *they* was also less masculine-biased than that of males. Evidence of continuing prescriptive pressure included the cross-age phenomenon of pronoun avoidance in writing when the referent was inclusive or feminine. However, correlations of age with education and occupation further suggested that a steady middle-class shift away from prescriptive "generic *he*" has been underway in colloquial English since at least the end of World War II. Suggested research directions include historical study of feminist linguistic thought and sociolinguistic field observations of contemporary generic pronoun usage. (Pronominal gender, agreement, woman suffrage, sociolinguistics, feminism, usage, oral history, Philadelphia, Minneapolis, English)

The Semantics and Acquisition of Time in Language (Ph.D. Dissertation)

**Laura Wagner
IRCS-98-14**

This dissertation is about the structure of temporal semantics and children's acquisition of temporal language. It argues for the importance of investigating semantics both at the abstract level of linguistic structures and at the concrete level of the time-course of acquisition, as these two levels provide natural constraints for each other. With respect to semantics, it provides a computationally inspired analysis of tense, grammatical aspect and lexical aspect that uses finite state automata to dynamically calculate the progress of an event over a time interval. It is shown that the analysis can account for many well-known temporal phenomena, such as the different entailments of telic and atelic predicates in the imperfective aspect (the imperfective paradox), and the various unified and serial interpretations of sentences involving a cardinally quantified phrase, such as Three Ringlings visited Florida. With respect to children's acquisition of temporal language, the dissertation investigates the Aspect First hypothesis which states that children initially use tense and grammatical aspect morphology to mark the lexical aspect property of telicity. Two forced-choice comprehension experiments were conducted with children aged 2.5 to 5 years old to test children's understanding of tense and grammatical aspect morphology; in a control condition, open class cues were used to test children's conceptual competence with tense and grammatical aspect information independently of their competence with the relevant morphology (e.g., in the middle of and in a few seconds were the open class cues for imperfective aspect and future tense, respectively). Results showed that even the youngest children understood the concepts underlying tense and grammatical aspect as measured by their performance with the open class cues but they did not demonstrate adult competence with the closed class morphology for grammatical aspect and did so only marginally for tense. Comprehension of tense morphology preceded that of grammatical aspect morphology and in particular, children showed an early facility with markers of the future tense.

Maximum Entropy Models for Natural Language Ambiguity Resolution (Ph.D. Dissertation)

**Adwait Ratnaparkhi
IRCS-98-15**

This thesis demonstrates that several important kinds of natural language ambiguities can be resolved to state-of-the-art accuracies using a single statistical modeling technique based on the principle of maximum entropy.

We discuss the problems of sentence boundary detection, part-of-speech tagging, prepositional phrase attachment, natural language parsing, and text categorization under the maximum entropy framework. In practice, we have found that maximum entropy models offer the following advantages:

* **State-of-the-art Accuracy:** The probability models for all of the tasks discussed perform at or near state-of-the-art accuracies, or outperform competing learning algorithms when trained and tested under similar conditions. Methods which outperform those presented here require much more supervision in the form of additional human involvement or additional supporting resources.

* **Knowledge-Poor Features:** The facts used to model the data, or features, are linguistically very simple, or "knowledge-poor", but yet succeed in approximating complex linguistic relationships.

* **Reusable Software Technology:** The mathematics of the maximum entropy framework are essentially independent of any particular task, and a single software implementation can be used for all of the probability models in this thesis.

The experiments in this thesis suggest that experimenters can obtain state-of-the-art accuracies on a wide range of natural language tasks, with little task-specific effort, by using maximum entropy probability models.

Hybrid Languages and Temporal Logic Patrick Blackburn and Miroslava Tzakova IRCS-98-16

Hybridization is a method invented by Arthur Prior for extending the expressive power of modal languages. Although developed in interesting ways by Robert Bull, and by the Sofia school (notably, George Gargov, Valentin Goranko, Solomon Passy and Tinko Tinchev), the method remains little known. In our view this has deprived temporal logic of a valuable tool.

The aim of the paper is to explain why hybridization is useful in temporal logic. We make two major points, the first technical, the second conceptual. First, we show that hybridization gives rise to well-behaved logics that exhibit an interesting synergy between modal and classical ideas. This synergy, obvious for hybrid languages with full first-order expressive strength, is demonstrated for a weaker local language capable of defining the Until operator; we provide a minimal axiomatization, and show that in a wide range of temporally interesting cases extended completeness results can be obtained automatically. Second, we argue that the idea of sorted atomic symbols which underpins the hybrid enterprise can be developed further. To illustrate this, we discuss the advantages and disadvantages of a simple hybrid language which can quantify over paths.

Where To Look? Automating Some Visual Attending Behaviors of Human Characters
(Ph.D. Dissertation Proposal)
Sonu Chopra
IRCS-98-17

We propose a method for automatically generating the appropriate attentional (eye gaze or looking) behavior for virtual characters existing or performing tasks in a dynamically changing environment. Such behavior is expected of human-like characters but is usually tedious to animate and often not specified at all as part of the character's explicit actions. In our system, referred to as the AVA (Automated Visual Attending), users enter a list of motor or cognitive actions as input in text format: walk to the lamp post, monitor the traffic light, reach for the box, etc.). The system generates the appropriate motions and automatically generates the corresponding attentional behavior. The resulting gaze behavior is produced not only by considering the explicit queue of required tasks, but also by factoring in involuntary visual functions known from human cognitive behavior (attentional capture by exogenous factors, spontaneous looking), the environment being viewed, task interactions, and task load. This method can be adapted to eye and head movement control for any facial model.

A Lexicalized Tree Adjoining Grammar for English
The XTAG Research Group
IRCS-98-18

This document describes a sizable grammar of English written in the TAG formalism and implemented for use with the XTAG system. This report and the grammar described herein supersedes the TAG grammar described in the earlier 1995 XTAG technical report. The English grammar described in this report is based on the TAG formalism developed in [Joshi et al, 1975], which has been extended to include lexicalization ([Schabes et al, 1988]), and unification-based feature structures ([Vijay-Shanker and Joshi, 1991]). The range of syntactic phenomena that can be handled is large and includes auxiliaries (including inversion), copula, raising and small clause constructions, topicalization, relative clauses, infinitives, gerunds, passives, adjuncts, it-clefts, wh-clefts, PRO constructions, noun-noun modifications, extraposition, determiner sequences, genitives, negation, noun-verb contractions, sentential adjuncts and imperatives. This technical report corresponds to the XTAG Release 8/31/98. The XTAG grammar is continuously updated with the addition of new analyses and modification of old ones, and an online version of this report can be found at the XTAG web page: <http://www.cis.upenn.edu/~xtag>.

Computer-Assisted Writing System: Improving Readability with Respect to Information Science
Nobo Komagata
IRCS-98-19

Text coherence and readability in English can be significantly affected by the organization of information in an utterance. To assist writers in this respect, we implement a Computer-Assisted Writing system focusing on 'information structure'. The main challenge in this task is identification of information structure in texts. This paper shows that this can be done by checking discourse status and linguistic marking in utterances.

Contrastive Function of Japanese Particle WA
Nobo Komagata
IRCS-98-20

The Japanese 'adverbial particle' WA is usually argued to have topic and contrastive functions. The previous analyses on contrastive function of WA have two problems. First, they fail to account for 'association with contrast' in complex NP. Second, the notion of contrast has not been made explicit enough to account for an asymmetry between contrasts involving and not involving WA. This paper assumes that the basic contrastive meaning is carried by phonological prominence, and argues that WA interacts with such a contrast resulting in a distinct presupposition, following 'alternative semantics' of Rooth.

Topic Segmentation: Algorithms and Applications (Ph.D. Dissertation)
Jeff Reynar
IRCS-98-21

Most documents are about more than one subject, but the majority of natural language processing algorithms and information retrieval techniques implicitly assume that every document has just one topic. The work described herein is about clues which mark shifts to new topics, algorithms for identifying topic boundaries and the uses of such boundaries once identified.

A number of topic shift indicators have been proposed in the literature. We review these features, suggest several new ones and test most of them in implemented topic segmentation algorithms. Hints about topic boundaries include repetitions of character sequences, patterns of word and word n-gram repetition, word frequency, the presence of cue words and phrases and the use of synonyms. The algorithms we present use cues singly or in combination to identify topic shifts in several kinds of documents. One algorithm tracks compression performance, which is an indicator of topic shift because self-similarity within topic segments should be greater than between-segment similarity. Another technique relies on word repetition and places boundaries by minimizing word repetitions across segment boundaries. A third method compares the performance of a language model with and without knowledge of the contents of preceding sentences to determine whether a topic shift has occurred. We use the output of this algorithm in a statistical model which

incorporates synonymy, bigram repetition and other features for topic segmentation.

We benchmark our algorithms and compare them to algorithms from the literature using concatenations of documents, and then perform further evaluation of our techniques using a collection of news broadcasts transcribed both by annotators and using a speech recognition system. We also test the effectiveness of our algorithms for identifying both chapter boundaries in works of literature and story boundaries in Spanish news broadcasts. We suggest ways to improve information retrieval, language modeling and various natural language processing algorithms by exploiting the topic segmentation.

Human Simulations of Vocabulary Learning

Jane Gillette, Henry Gleitman, Lila Gleitman, and Anne Lederer

IRCS-98-22

The work reported here experimentally investigates a striking generalization about vocabulary acquisition: Noun learning is superior to verb learning in the earliest moments of child language development. The dominant explanation of this phenomenon in the literature invokes differing conceptual requirements for items in these lexical categories: Verbs are cognitively more complex than nouns and so their acquisition must await certain mental developments in the infant. In the present work, we investigate an alternative hypothesis; namely, that it is the information requirements of verb learning, not the conceptual requirements, that crucially determine the acquisition order. Efficient verb learning requires access to structural features of the exposure language and thus cannot take place until a scaffolding of noun knowledge enables the acquisition of clause-level syntax. More generally, we experimentally investigate the hypothesis that vocabulary acquisition takes place via an incremental constraint-satisfaction procedure that bootstraps itself into successively more sophisticated linguistic representations which, in turn, enable new kinds of vocabulary learning. If the experimental subjects were young children, it would be difficult to distinguish between this information-centered hypothesis and the conceptual change hypothesis. Therefore the experimental learners are adults. The items to be "acquired" in the experiments were the 24 most frequent nouns and 24 most frequent verbs from a sample of maternal speech to 18-24-month old infants. The various experiments ask about the kinds of information that will support identification of these words as they occur in mother-to-child discourse. In Experiment 1, subjects were required to identify the words from observing several extralinguistic contexts for their use (silent videos in which mothers are seen uttering the "mystery word" several times to the infants, with each such use cued by a beep or a nonsense word). The findings under these conditions mimicked the known learning trajectory for infants at the inception of

speech and comprehension: Nouns are learned far more efficiently than verbs. Experiment 2 showed that the Experiment 1 results are best understood as concreteness differences that are correlated with lexical class membership in the common usage of mothers to young children. Experiment 3 presented (different) subject groups with 24 verbs under varying information Conditions; namely: (1) extralinguistic information; (2) noun-co-occurrence information; (3) both (1) and (2); (4) syntactic-frame information but with nouns and verbs represented by nonsense words; (5) both (2) and (4); (6) both (1) and (5). Each Condition led to greater identification success than the preceding Condition. Moreover, not only the number but the type of verb that was efficiently learned was different under the different information conditions. We discuss these results as consistent with the incremental construction of a highly lexicalized grammar by cognitively and pragmatically sophisticated human infants, but inconsistent with a procedure in which lexical acquisition is independent of and antecedent to syntax acquisition.

Modality in Dialogue: Planning, Pragmatics and Computation (Ph.D. Dissertation)

Matthew Stone

IRCS-98-23

Natural language generation (NLG) is first and foremost a reasoning task. In this reasoning, a system plans a communicative act that will signal key facts about the domain to the hearer. In generating action descriptions, this reasoning draws on characterizations both of the causal properties of the domain and the states of knowledge of the participants in the conversation. This dissertation shows how such characterizations can be specified declaratively and accessed efficiently in NLG.

The heart of this dissertation is a study of logical statements about knowledge and action in modal logic. By investigating the proof-theory of modal logic from a logic programming point of view, I show how many kinds of modal statements can be seen as straightforward instructions for computationally manageable search, just as Prolog clauses can. These modal statements provide sufficient expressive resources for an NLG system to represent the effects of actions in the world or to model an addressee whose knowledge in some respects exceeds and in other respects falls short of its own. To illustrate the use of such statements, I describe how the SPUD sentence planner exploits a modal knowledge base to assess the interpretation of a sentence as it is constructed incrementally.

Incorporating Punctuation into the Sentence Grammar: A Lexicalized Tree Adjoining Grammar Perspective (Ph.D. Dissertation)
Christine D. Doran
IRCS-98-24

Most current natural language processing systems fail to take punctuation into account, losing a valuable source of information about the text. Those which do mostly do so in a superficial way, again failing to fully exploit the information conveyed by punctuation. To be able to make use of such information in a computational system, we must first characterize its uses and find a suitable representation for encoding them. The work here focuses on extending a syntactic grammar to handle phenomena occurring within a single sentence which have punctuation as an integral component. Punctuation marks are treated as full-fledged lexical items in a Lexicalized Tree Adjoining Grammar, which is an extremely well-suited formalism for encoding punctuation in the sentence grammar. I have analyzed data representing a wide variety of constructions, and added treatments of them to the large English grammar which is part of the XTAG system. The advantages of using LTAG are that its elementary units are structured trees of a suitable size for stating the constraints we are interested in, and the derivation histories it produces contain information the discourse grammar will need about which elementary units have used and how they have been combined. I also consider in detail a few particularly interesting constructions where the sentence and discourse grammars meet---appositives, reported speech and uses of parentheses. My results confirm that punctuation can be used in analyzing sentences to increase the coverage of the grammar, reduce the ambiguity of certain word sequences and facilitate discourse-level processing of the texts.

On Relational Completeness of Multi-Modal Categorical Logics
Gerhard Jaeger
IRCS-98-25

Several recent results show that the Lambek Calculus L and its close relative L1 is sound and complete under (possibly relativized) relational interpretation. The paper transfers these results to L-diamond, the multi-modal extension of the Lambek Calculus that was proposed in Moortgat 1996. Two natural relational interpretations of L-diamond are proposed and shown to be sound and complete. The completeness proofs make heavy use of the method of relational labeling from Kurtonina 1995. Finally, it is demonstrated that relational interpretation provides a semantic justification for the translation from L-diamond to L from Versmissen 1996.

On the Generative Capacity of Multi-Modal Categorical Grammars
Gerhard Jaeger
IRCS-98-26

In Moortgat 1996 the Lambek Calculus L (Lambek 1958) is extended by a pair of residuation modalities "diamond" and "box". Categorical Grammars based on the resulting logic L-diamond are attractive for linguistic purposes since they offer a compromise between the strict constituent structure imposed by context free grammars and related formalisms on the one hand, and the complete absence of hierarchical information in Lambek grammars on the other hand. The paper contains some results on the generative capacity of Categorical Grammars based on L-diamond. First it is shown that adding residuation modalities does not extend the weak generative capacity. This is proved by extending the proof for the context freeness of L-grammars from Pentus 1993 to L-diamond. Second, the strong generative capacity of L-diamond grammars is compared to context free grammars. The results are mainly negative; the set of tree languages generated by L-diamond grammars neither contains nor is contained in the class of context free tree languages.

Motion Planning and Control of Cooperative Robotic Systems (Ph. D. Dissertation)
Jaydev P. Desai
IRCS-98-27

This thesis addresses the problem of motion planning for cooperative robotic systems. The problem of motion planning for a robotic system is stated as: Given initial positions and orientations and goal positions and orientations for a collection, C, of robots, in workspace, W, generate a continuous trajectory for C avoiding contact with the obstacles, O_i, subject to various dynamical constraints of the system.

Because robots are physical systems subject to continuous laws of motion and driven by continuous actuators, we formulate the motion planning problem as an unconstrained variational problem using tools from optimal control and calculus of variations in the first part of the thesis. We develop a general framework for solving motion planning problems involving equality and inequality constraints.

In the second part of the thesis, we study planar human manipulation and develop a computational model for friction-assisted dual arm manipulation tasks incorporating the dynamics of the musculo-skeletal system. We show that our computational model predicts the force distribution and object trajectory in voluntary, relaxed movements. We further study similar tasks in the vertical plane and our experimental findings suggest that there is a great degree of repeatability in trajectories and velocity profiles across trials and subjects.

In the third part, we focus on extending this computational model to plan and control cooperative robotic systems. We solve the dynamic motion planning problem for a system of cooperating robots in the presence of geometric and kinematic constraints, and test the resulting open-loop trajectories on the experimental testbed. In the last part of the thesis, we explore the application of the motion planning algorithms when the number of robots in C is very large. Because of increased computational time, we use optimal sensor-based closed loop motion plans. These are combined with the framework of graph theory and optimal control to guarantee provable measure on the performance of the entire system.

The main contributions of the thesis are: (a) studying trajectory generation and force distribution in human dual arm manipulation; and (b) a set of motion planning algorithms for cooperating robot systems subject to dynamic constraints.

Automatic Construction of Chinese-English Translation Lexicons

I. Dan Melamed and Mitch Marcus
IRCS-98-28

The process of constructing translation lexicons from parallel texts (bitexts) can be broken down into three stages: mapping bitext correspondence, counting co-occurrences, and estimating a translation model. State-of-the-art techniques for accomplishing each stage of the process had already been developed, but only for bitexts involving fairly similar languages. Correct and efficient implementation of each stage poses special challenges when the parallel texts involve two very different languages. This report describes our theoretical and empirical investigations into how existing techniques might be extended and applied to Chinese/English bitexts.

The Structure and Interpretation of Imperatives: Mood and Force in Universal Grammar (Ph.D. Dissertation)

Chung-hye Han
IRCS-98-29

This dissertation is a cross-linguistic investigation into the structure and interpretation of imperatives and related constructions. We identify universal morphosyntactic principles of imperatives and explain variations in the syntax of imperatives as a consequence of the interaction between the universal principles and the morphosyntactic system of a particular language. Based on these conclusions, we develop a model for the interpretation of imperatives. We show that the syntax of imperatives across languages includes an imperative operator, which is a set of morphosyntactic features. The interaction between a formal universal for the imperative operator and the syntax of a language correctly predicts the cross-linguistic variation in the availability of negative imperatives. We also account for the apparent peculiarity in the syntactic evolution of imperatives in the history of English.

The results of our analysis confirm the postulated presence of an imperative operator and provide support for the presence of particular functional projections in the clausal phrase structure in English. We also propose that the morphosyntactic features of the imperative operator have interpretational consequences. We argue that the imperative operator includes a feature that encodes directive force, and another feature that encodes modality of unrealized interpretation. We also argue that subjunctives and infinitivals have an operator whose feature content is in a proper subset relation with that of the imperative operator. By defining the relation of imperatives, subjunctives and infinitivals in this way, we are able to capture the close relation that exists in many languages between these three types of sentences. We also account for the cross-linguistic variation in the syntactic behavior of the imperative subject by developing the idea that the imperative operator selects either an infinitive type or subjunctive type INFL, depending on the language. We define directive illocutionary force as an instruction to the hearer to update a 'plan set,' a set of propositions that specifies the hearer's intentions. Thus, the directive force of the imperative is not a result of inference; it is directly encoded in its logical form.