INTELLIGENT SYSTEMS RESEARCH GROUP

by

Lois C. Boggess lboggess@cs.msstate.edu
Julian E. Boggess gboggess@cs.msstate.edu
Susan M. Bridges bridges@cs.msstate.edu
Bradley D. Carter carter@cs.msstate.edu
R. Dwight Hare rdh1@ra.msstate.edu
Julia E. Hodges hodges@cs.msstate.edu
Joe Picone picone@isip.msstate.edu

Department of Computer Science, College of Eng.
Institute for Signal and Information Processing, College of Eng.
Instructional Technology Laboratory, ERC
Curriculum and Instruction, College of Edu.

Mississippi State University

ABSTRACT

We are a group with both mutual and complementary interests and strengths, in cognition, language, large bodies of data, multiple modes of communication between computer and humans, machine learning and adaptable systems. We've built systems in which the computer is seen as an aid to the human, rather than as the primary actor. Typically our goal is to achieve best possible performance when time constraints are sub-optimal, data are imperfect or incomplete, and there are multiple plausible ways for a system to proceed at any point in execution. These interests are supported by a core competency in a number of related information processing technologies including speech recognition, signal and image processing, natural language processing, machine learning, and expert database systems.

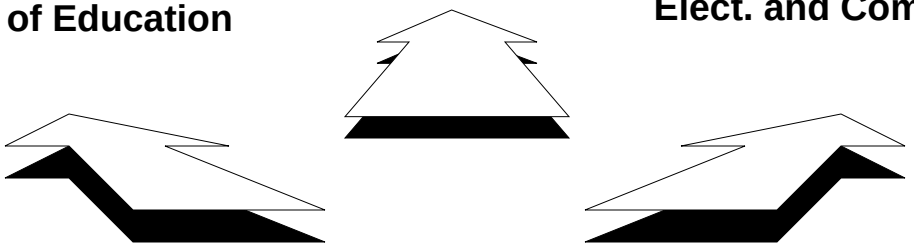
INTELLIGENT SYSTEMS RESEARCH GROUP

Computer Aided Instruction
Is Multidisciplinary By Nature

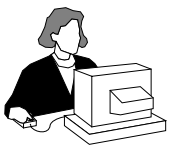
Gene Boggess
Lois Boggess
Susan Bridges
Julia Hodges
Computer Science

Dwight Hare
College of Education

Joe Picone
Elect. and Comp. Eng.



Brad Carter
Don Trotter
ERC



INTELLIGENT SYSTEMS RESEARCH GROUP

Intelligent Systems Research Needs
A Diverse Collection of Expertise and Experience

Brad Carter
Director of Education, ERC

- Software Engineering
- Software Metrics
- Instructional Technology

Lois Boggess
Computer Science

- Natural Language
- Very Large Corpora
- Intelligent Tutoring

Gene Boggess
Computer Science

- Cognitive Science
- Neural Networks
- Genetic Algorithms

Julia Hodges
Computer Science

- Knowledge Bases
- Database “Mining”
- Machine Learning

Susan Bridges
Computer Science

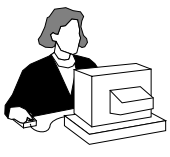
- Expert Systems
- Explanation-Based Learning
- Hybrid Systems

Dwight Hare
Curriculum and Instruction

- Learning and Pedagogy
- Classification
- Educational Policy

Joe Picone
Computer Engineering

- Speech Recognition
- Statistical Modeling
- Signal Processing



An Intelligent Tutoring System from the Mid-80's

Implementation:

- ❒ The Goal

  Identify and provide remediation for a set of math topics at the sixth-grade level for adults preparing for the GED.

- ❒ The Cognitive Model

  Extracted from State of Mississippi requirements for elementary teachers.

- ❒ Subjects

  At least third grade competence in reading

  Some were students of a teacher instructing for GED

  Some were prisoners taking GED classes.

- ❒ Evaluation and Testing

  System created pretest "on the fly" (filling slots in templates) so questions were not repeated.

  Students were given remediational material on subconcepts which appeared not to be mastered

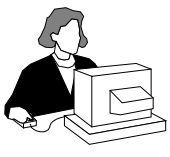
  System created posttest.

- ❒ System "successful"

  Statistically significant value added to student competence

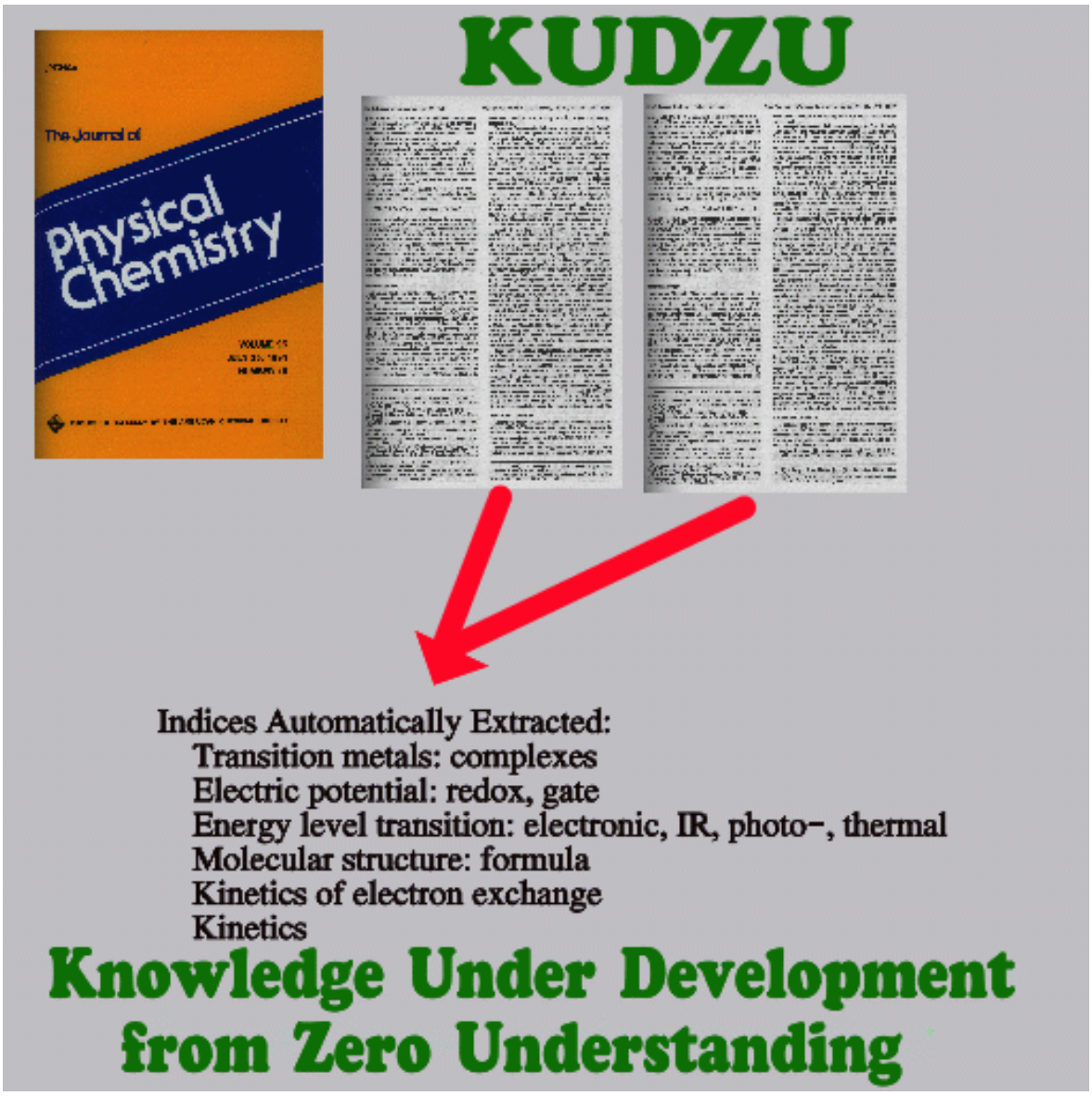
What did we learn?

- ❒ System did what it was designed to do
- ❒ No educational revolution followed
- ❒ A computerized book - with an attitude



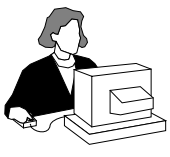
INTELLIGENT SYSTEMS RESEARCH GROUP

A Sampling of Mid-90's Research



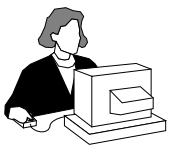
AIMS: Automated Indexing at Mississippi State

- ❒ Unrestricted vocabulary
- ❒ Domain dependent
- ❒ Embeds human expertise
- ❒ Partners with human document analyst
- ❒ Tools to tune system to the way language is used within domain



KUDZU: Knowledge Under Development from Zero Understanding

- ❒ Capture all the information present
- ❒ Open vocabulary
- ❒ Bootstrap a knowledge base
  Initially only metaknowledge of the domain
  Grows by reading the text



Common Themes

- Learning the lingo: Understanding language
  using cues in the language itself
- Information extraction:
  from human experts
  from large bodies of data
- Interactive systems, human-centered interfaces, multiple modes of communication
- Data mining
- Machine learning - supervised/unsupervised
- Classification

Characterization of Waste Assay Data

- Synthesis of data from multiple sources
  - database
  - multiple sensors
  - process history
- Determining confidence of characterization
  - consistency checking of data from multiple sources
  - confidence associated with data sources
- Knowledge discovery
  - detecting patterns in data
  - learning classification rules based on patterns

- One of the themes of “soft AI” is

> Graceful degradation

- Genetic algorithms, neural networks:

  Data driven

  Good performance with good data

  Reasonable performance in the presence of incomplete or missing data, erroneous input

Graceful accommodation to stretching the boundaries

- Instead of systems which define to the world the boundaries within which the world must fit, we choose to build
  - Systems in which the domain boundaries are fuzzy
  - Systems which do not impose limits in some important aspects
  - Human-centered systems

ISIP's Focal Projects

- An Integrated Services Transactions Processor That Supports Advanced Telecommunications Interfaces such as an Asynchronous Transfer Mode (ATM) Digital Communications Link

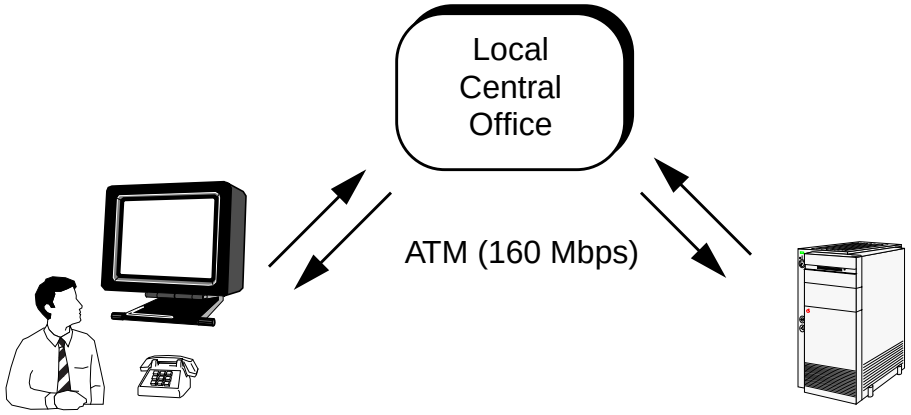
Example: Telephone-Based Natural Language Query of Entertainment Archives

Customer: "Give me all movies, uh, make that only the recent movies, directed by Martin Scorsese and starring Robert DeNiro, and oh, by the way, make that movies about gangsters only."

Computer: We have three titles available (the titles of the movies are shown on the television screen with real-time video of promo clips from each movie below the title). Please select a movie.

Customer: "That one with the three guys looks good, I'll take that one. I want it to start at 8:00 PM tomorrow."

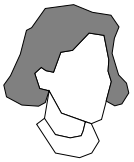
Computer: (The promo clip for the selected movie starts playing on the television.) The movie titled GoodFellas starring Robert DeNiro and directed by Martin Scorsese will be delivered for viewing on your television on Thursday, September 25 starting at 8:00 PM. Thank you for using ISIP's Entertainment Server. Good-bye.



- Voice
- Video
- Data (X Windows)

Unix Multiprocessor (Sparcstation 2000):
- 8 Processors
- 512 Mbytes of memory
- videotape jukebox

INTELLIGENT SYSTEMS RESEARCH GROUP



Speech Recognition

"Show me all the reports from the White House on Healthcare."

Text

Language Model

Natural Language Understanding

Natural Language Processing

Language Model

Tagged Text

Semi-Parser

Flat Parsed Structures

Knowledge Extraction

Knowledge Extractor

Filled Templates

Request Generator

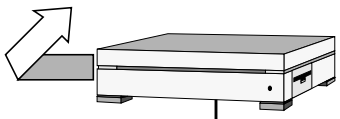
Netscape Requests

Netscape

INTELLIGENT SYSTEMS RESEARCH GROUP

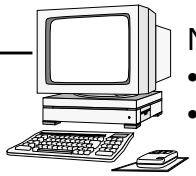
INTELLIGENT SYSTEMS RESEARCH GROUP

The ISIP Computer Network: isip.msstate.edu



Sparcstation 5 Fileserver
- 32 Mbytes RAM
- 2 Gbyte local disk
- 30 Gbytes external disk
- 1 Exabyte Stacker (50 Gbyte)
- 2 ethernets (Class C subnet)

Compute Server:
- Sparc 20/60
- 2 processors
- 192 Mbytes RAM
- 1 Gbyte local disk



NCD X Terminals
- 20” Color/Audio
- 15” B&W

Demo Machine:
- Sparcstation 5
- ATM Interface
- T1 Interface

Sony DATs
- 16-bit audio
- Networked

X/Audio Server:
- Sparc SLC
- 1 processor
- 32 Mbytes RAM
- 100 Mbyte disk
- TCT DAT-Links
- Network Audio

28.8K Baud Dialup
- LBW X Windows
- 115K TTYs

Color Scanner
- 300 dpi
- Adobe Photoshop

Sparcstation 1000
- 8 processors
- 500 Mbytes RAM
- Dedicated Server

B&W Printer
- postscript
- 600 dpi
- 12 ppm

URL: http://www.isip.msstate.edu
FTP: ftp://ftp.isip.msstate.edu

INTELLIGENT SYSTEMS RESEARCH GROUP

Basic Technology:
A Pattern Recognition Paradigm Based On Hidden Markov Models

Recognized Symbols: $P(S|\boldsymbol{O}) = \arg max|_T \prod_i P(W_t^i|(\vec{O}_t, \vec{O}_{t-1}, \ldots))$

Language Model: $P(W_t^i)$

Search Algorithms: $P(W_t^i|\boldsymbol{O}_t) = \frac{P(\boldsymbol{O}_t|W_t^i)P(W_t^i)}{P(\boldsymbol{O}_t)}$

Prediction

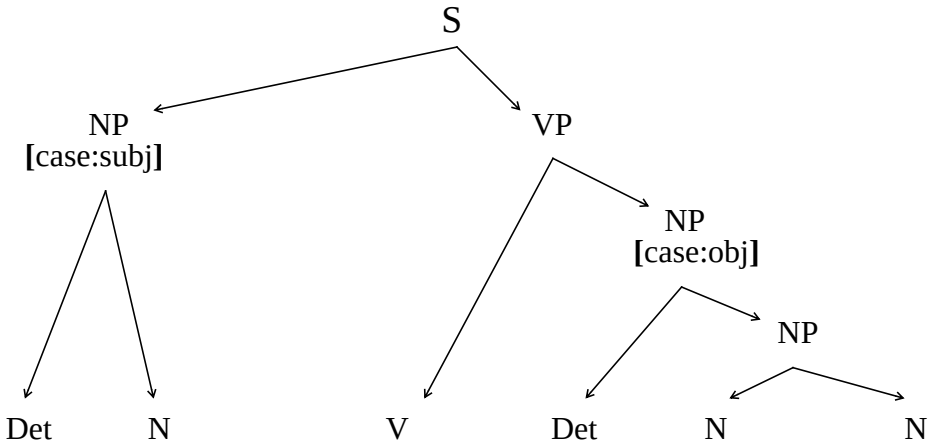
Pattern Matching: $[W_t^i, P(\vec{O}_t, \vec{O}_{t-1}, \ldots|W_t^i)]$

Signal Model: $P(\vec{O}_t|(W_{t-1}, W_t, W_{t+1}))$

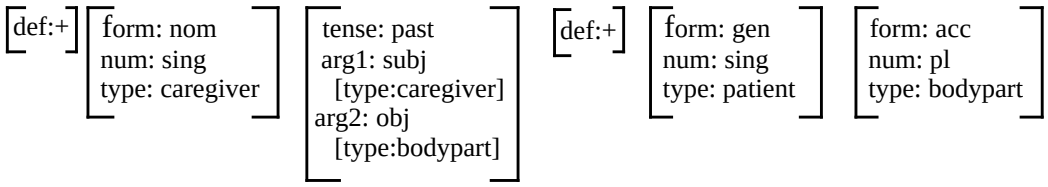
What can you do with all of this?

Logical: ∃(X) & ∃(Y) & ∃(Z) & doctor(X) & patient(Y) & knees(Z) & part-of(Y,Z) & examined(X,Z)

Syntactic:



Lexical:

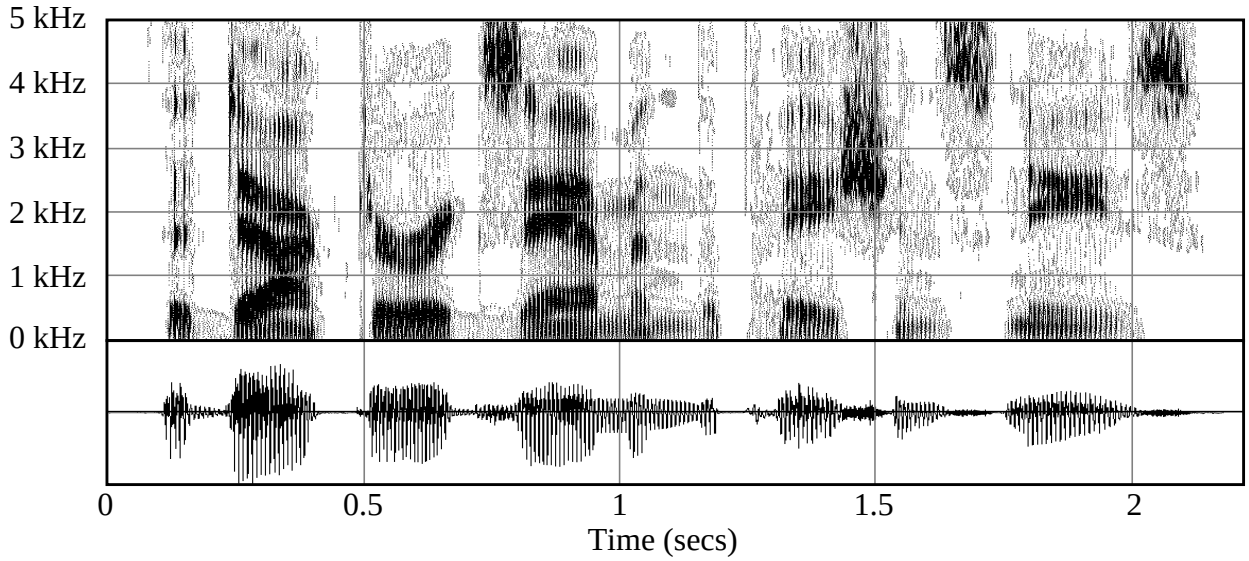


Orthographic: The doctor examined the patient's knees.

Phonemic: /# dh i # d A k t exr # I g z ae m ex n + d # dh i # p e sh ex n t + z # n i + z #/

Phonetic: dh ex d A k t exr I g z ae m I n d dhex pH e-I sh I nt s n i: z

Phonetic: dh ex d A k t exr I g z ae m I n d dhex pH e-I sh I nt s n i: z



Human Speech Recognition Performance Benchmarks On ARPA SLT CSR Corpora

CSR'94: SPOKE 10

Evaluation Group	Vocabulary	
	Open	Closed
Average	2.1 (0.7)	1.0 (0.6)
Committee	1.2 (0.6)	0.5 (0.6)

CSR'95: HUB-3

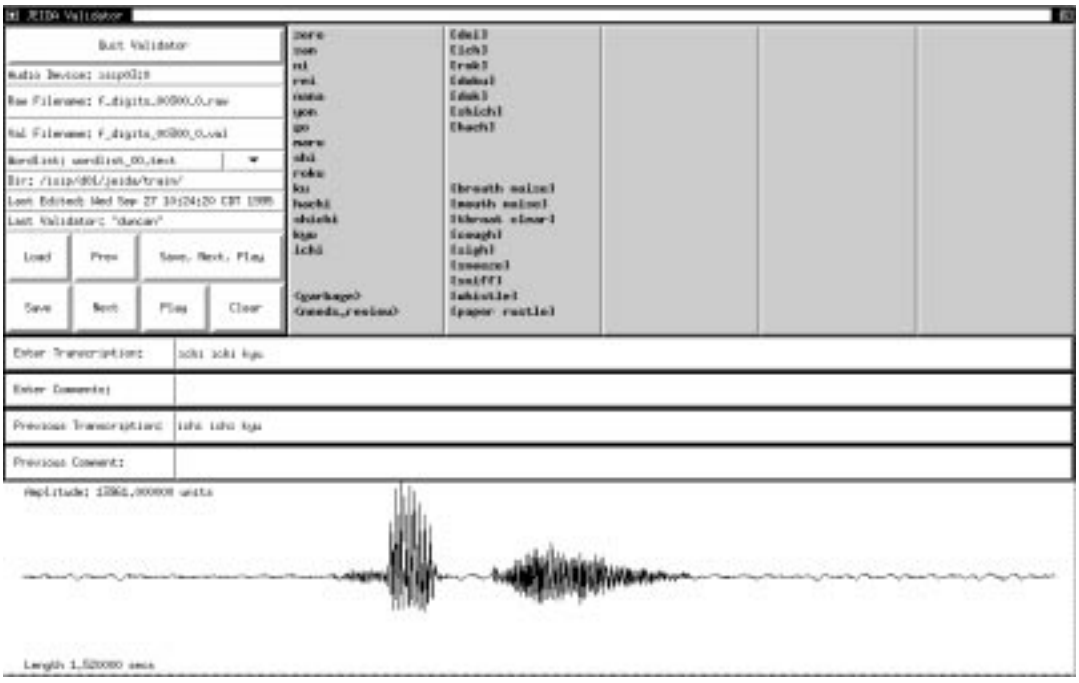
Evaluation Group	Vocabulary	
	Open	Closed
Average	2.2	2.1
Committee	0.5	0.5

- *Overall human performance is at least an order of magnitude better than machine performance*

INTELLIGENT SYSTEMS RESEARCH GROUP

The JEIDA Japanese Common Speech Data Corpus

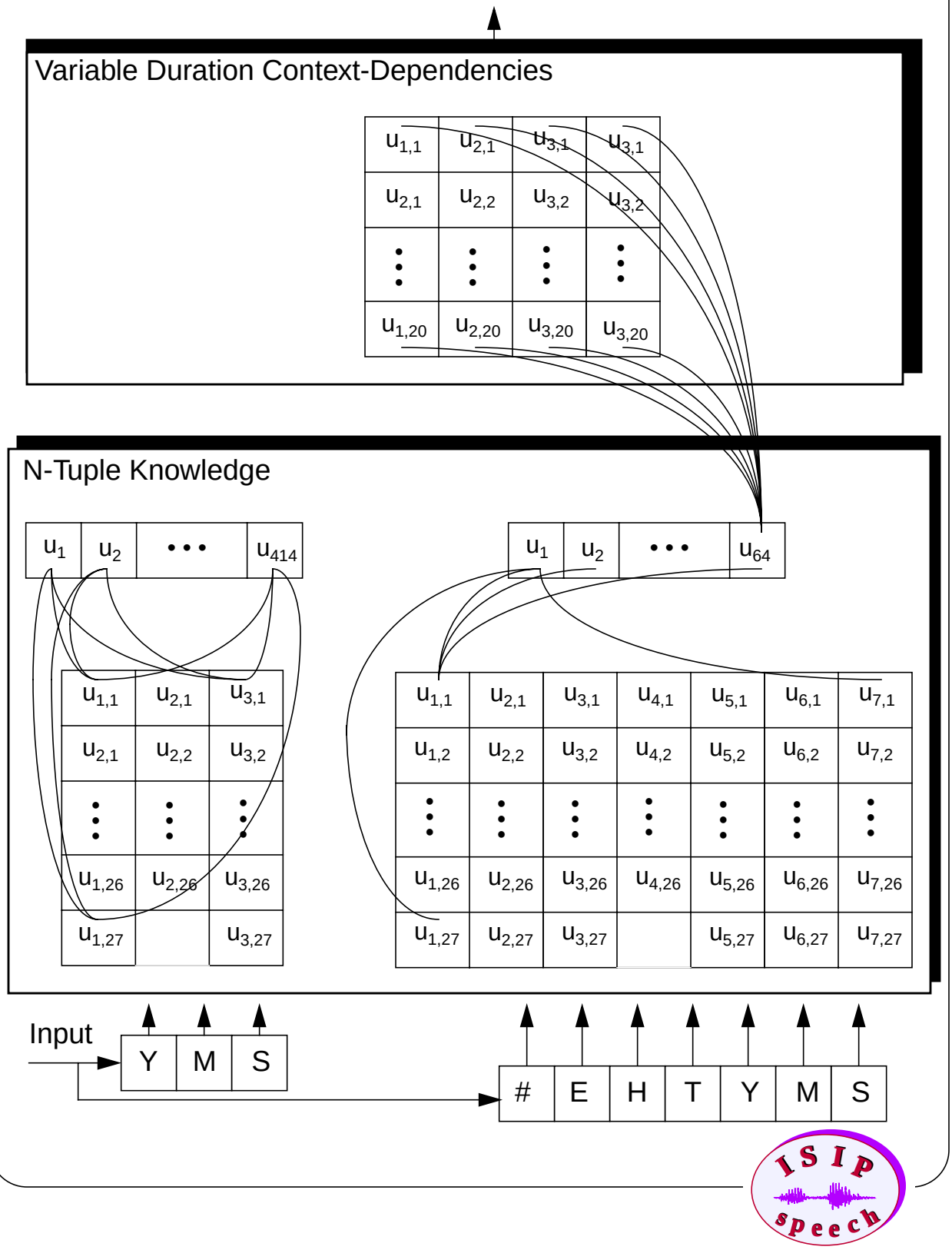
Number of speakers	150 speakers 75 male speakers 75 female speakers
Number of items per speaker monosyllables 178 isolated words 35 4-digit sequences	323 items
Number of repetitions per item	4 repetitions of each item
Range of speaker age	20 yrs. to 60 yrs.
Amount of data	120 hours
Number of Digital Audio Tapes	76 (120-minute tapes)
Total number of utterances	193,800 utterances
Number of channels/mic. type	2 (dynamic and condenser mics.)
Anticipated size of final corpus (16-bit 16 kHz samples @ 1.0 secs per utterance)	6.5 Gbytes (13 CD-ROMs uncompressed)



INTELLIGENT SYSTEMS RESEARCH GROUP

Automatic Generation of N-Best Proper Noun Pronunciations

{s: -voiced, ...} {m: +nasal,...} {(ay: +voiced,...), (ih: +voiced,...)} ...



INTELLIGENT SYSTEMS RESEARCH GROUP

What Differentiates ISIP Speech Research?

- Public Domain Software
- Extensive Web Archive
- Object-Oriented Signal Processing Software
- State-of-the-Art Performance Tasks
- Close Industrial Ties
- Next-Generation Statistical Models Based on Chaotic Systems

  Applicable to acoustic and language modeling
  Addresses a fundamental barrier in speech understanding