Language Technologies Institute

Faculty Research Areas

Carnegie Mellon University
School of Computer Science
Jeff Bingham  |  Associate Professor

CROWD-POWERED CONVERSATIONAL ASSISTANTS
• Creating robust dialog systems using on-demand human computation
• Crowd-powered assistants that automate themselves over time

TOOLS FOR CROWD WORKERS
• Applying AI to amplify workers abilities, and help workers improve their skills and earnings

DYSLEXIA DETECTION AND INTERVENTION
• Using linguistics and human-computer interaction measures to detect dyslexia
• Building tools that help people with dyslexia read and write better

Yonatan Bisk  |  Assistant Professor

EMBODIED AI
• Can we learn language from robots?
• Can we control robots with language?

GROUNDING / MULTIMODAL
• Can models capture both concrete and abstract thought?
• What knowledge about the world can’t be learned from text?

Ralf Brown  |  Principal Systems Scientist

INFORMATION EXTRACTION
• Text normalization

LANGUAGE IDENTIFICATION
• Identifying short texts in 1000+ languages

DIGITAL FORENSICS
• Text extraction
• Reconstructing corrupted files

Jamie Callan  |  Professor & Director, PhD Program

SEARCH ENGINE ARCHITECTURES
• Discrete and continuous text representations
• Heuristic and neural search architectures
• Search using knowledge and semi-structured information
• Conversational search

THE LEMUR PROJECT
• Open-source search engine and text mining software
• Large-scale web datasets
Mona Diab  |  LTI Director

**Computational Linguistics/Natural Language Processing**
- Conversational AI
- Computational lexical semantics
- Multilingual and cross-lingual processing

**Social Media Processing**
- Computational socio-pragmatics
- Information extraction
- Text Analytics
- Machine Translation

Fernando Diaz  |  Associate Professor

**Information Retrieval Algorithms**
- Design of search engines that enhance machine learning systems
- Support of on-line human information needs

**Evaluation of Language Technologies**
- Measurement of unfairness and other harms in language technologies
- Identification and measurement of the impact of artificial intelligence on culture industries such as music, film, and literature
- Design of effective and efficient foundational metrics for offline and online evaluation

Scott E. Fahlman  |  Professor Emeritus, LTI & CSD

**Symbolic Knowledge Representation and Reasoning**
- Ongoing research on the open-source Scone knowledge-base system
- Flexible, human-like, "good-enough" planning, integrated with world-knowledge

**Knowledge-Based Natural Language Understanding and Generation**
- Going all the way from text or speech to a useful representation of the knowledge
- Using context and background knowledge for disambiguate and fill in missing information

**Incrementally Constructed Networks for Deep Learning**
- Updating some old ideas about gradually building up neural networks to fit the task at hand

Robert Frederking  |  Assoc. Dean, Doctoral Programs, SCS & Chair, MLT Program

**Machine Translation**
- Speech translation
- Endangered language support

**Natural Language Applications**
- Information extraction from text
Daniel Fried  |  Assistant Professor
GROUNDED INTERACTION
• Grounding language to perception and action
• Language interfaces
CODE GENERATION
• Language-to-code
• Interaction with code generation models
APPLIED PRAGMATICS
• Understanding implicit language
• Contextual language understanding & generation

Alex Hauptmann  |  Research Professor
MULTIMEDIA ANALYSIS AND RETRIEVAL
• Large scale analysis of internet and surveillance video
• Multimedia for healthcare
• Multimedia for human rights

Daphne Ippolito  |  Assistant Professor
NEURAL LANGUAGE MODELS
• Privacy, security, and ethical concerns
• Training dataset construction
• Decoding strategies
• Detection of generated text
USES OF NATURAL LANGUAGE GENERATION
• Building interactive tools for creative writers
• Real-world evaluation of language generation systems

Lori Levin  |  Research Professor
MULTILINGUAL NATURAL LANGUAGE PROCESSING
• Using linguistics and language typology to improve NLP
• Low resource languages
• Corpus annotation (syntax, semantics, morphosyntax)
NORTH AMERICAN COMPUTATIONAL LINGUISTICS OPEN COMPETITION (NACLO)
• Co-chair
• Students learn about linguistics and computation by solving puzzles
Lei Li | Assistant Professor

LARGE LANGUAGE MODELS
- Security, Safety, Privacy, Copyright of LLM
- LLM Agent, reasoning, code generation, tool use, cooperation
- Efficient LLM systems

MULTILINGUAL NLP
- Machine Translation (how to translate 1000 languages?)
- Speech Translation
- Multilingual Transfer

AI FOR SCIENCE
- AI for Drug Discovery, design effective small molecule drugs for disease target
- Generative Algorithms for Protein Design (design proteins with desired biochemical functions)

Teruko Mitamura | Research Professor & Director, MIIS Program

TEXT ANALYSIS
- Events; Definition, detection, coreference, sequence, linking and representation
- Annotation on event and entity mentions and linking

QUESTION ANSWERING
- Question answering on various domains
- Question generation and answering from text

COMPUTER-ASSISTED LANGUAGE LEARNING
- Intelligent reading system for English

Louis-Philippe Morency | Associate Professor

ARTIFICIAL SOCIAL INTELLIGENCE
- Analyze, recognize and predict subtle human communicative behaviors during social interactions

MULTIMODAL MACHINE LEARNING
- Learning probabilistic and neural models from heterogenous, contingent and asynchronous data

HEALTH BEHAVIOR INFORMATICS
- Technologies to support clinical practice during diagnosis and treatment of mental health disorders

David R. Mortensen | Assistant Research Professor

RESOURCES
- Speech and language data resources for speech and NLP

COMPUTATIONAL MODELS OF LANGUAGE STRUCTURE
- Modeling and exploiting sound structure in natural language processing
- Computational models of word structure
- Modeling language change and historical reconstruction of languages
- Linguistic evaluation of large language models

MODELING DIVERSITY IN LANGUAGE AND CULTURE
- Linguistic typology
- Culture variation in natural language processing
Graham Neubig  |  Assistant Professor

MACHINE LEARNING FOR NATURAL LANGUAGE PROCESSING
• Large Language Models and Applications
• Automated Machine Learning (AutoML)
• Efficient and Effective Evaluation

NATURAL LANGUAGE INTERFACES TO COMPUTERS
• Code Generation
• AI Agents and Chatbots

MULTILINGUAL AND MULTIMODAL LANGUAGE PROCESSING
• Low-resource Language Processing
• Multilingual Multimodal Models
• Computational Linguistics

Eric Nyberg  |  Professor

OPEN ADVANCEMENT OF QUESTION ANSWERING
• Software architectures and algorithms for real-world QA applications (e.g., Jeopardy! Challenge, BioASQ, LiveQA)

MACHINE READING
• Mixed-initiative information extraction, logical form creation and inference for automatic knowledge-base construction in any domain

INTERACTIVE ANALYTIC LEARNING
• Reducing cost of training high-quality analytics for new domains

Kemal Oflazer  |  Teaching Professor

TEXT SIMPLIFICATION
• Generating short summaries or headlines from (Turkish) news stories

NLP APPLICATIONS
• Using NLP techniques to automate and improve student Q/A in Piazza-like courseware settings

COMPUTATIONAL MORPHOLOGY
• Going beyond morphological segmentation for inducing morpho-semantic representations
• Handling segmentation ambiguity

Bhiksha Raj  |  Professor

AUDIO ANALYSIS
• Audio content analysis, with applications to acoustic intelligence, surveillance, content-based retrieval
• Never ending learner of sound: a self-updating audio-content index for the web
• Signal enhancement and separation algorithms

PRIVACY PRESERVING SIGNAL PROCESSING
• Algorithms to preserve user privacy in speech & audio applications
• Secure cloud computing techniques

SPEECH PROCESSING
• Robust speech recognition and core speech recognition technologies

DEEP NEURAL NETWORKS
• Novel applications of deep networks and algorithms for practical deployment of deep networks
Carolyn P. Rosé  |  Professor LTI & HCII & Director, MCDS Program

Text Mining/Computational Sociolinguistics
- Modeling social processes in discourse
- Deep learning of rhetorical structure
- Social Media Analysis
- Medical NLP

Dialogue Agents
- Reinforcement Learning for Adaptable Dialogue Agents
- Dialogue agents for Learning, Health, and Wellbeing

Computer-Supported Collaborative Learning
- Architectures for supporting online collaboration
- Social Recommendation Algorithms
- Learning in Massive Open Online Courses

Roni Rosenfeld  |  Professor

- Epidemic Tracking and Forecasting (Delphi Group)
- Machine Learning and Society
- Machine Learning

Alexander Rudnicky  |  Research Professor Emeritus

Conversational AI and Speech Recognition
- Open-domain conversation architectures
- Goal-oriented dialog systems
- Spoken language understanding and situational awareness
- Emotion recognition from speech audio

Spoken Language Systems
- Dialog system architectures and dialog management using implicit state spaces
- Spoken language understanding and situational awareness based on levels of context
- Speech recognition for interactive systems
- Speaker emotion recognition from speech audio

Maarten Sap  |  Assistant Professor

Social Commonsense Reasoning
- Develop knowledge formalisms and representations for distilling social commonsense knowledge for machines
- Create algorithms for more socially aware AI and NLP system e.g., for assistive, therapeutic, or educational technology

Toxicity and Social Biases in Language
- Design holistic and explainable formalisms and models for detecting social biases & toxicity in language
- Develop mitigation algorithms for toxic language rewriting and counterspeech generation

Diagnose and mitigate the fairness of AI and NLP systems
- Investigate the fairness of models with respect to marginalized populations, with empirical and human-centered methods
Mathematical Discovery
- Mathematics as a language
- Automated discovery of mathematical relationships via AI
- Mathematical searching

AI Law
- Development of meaningful AI regulations

Rita Singh | Associate Research Professor

- Voice Intelligence and Security
- Human profiling from voice
- Generalized AI Models for Speech and Audio Processing
- Multimedia and Cyber Forensics
- Human-Guided and Creative AI
- Quantum Computing

Emma Strubell | Assistant Professor

Efficient NLP/Green AI
- How to obtain state-of-the-art model accuracy while reducing computation, memory, carbon footprint?
- Which model parameters, training examples are necessary/sufficient for learning effective models?
- How to set up parameter learning, model architecture to facilitate efficient inference?

Robust Out-of-Domain/Out-of-Distribution Performance:
- Transfer learning, learning from few examples, weak supervision.
- How to effectively integrate structured information/priors alongside distributed representations?

Practical Structured Interfaces for Natural Language Texts
- Representations that facilitate learning/inference as well as analysis by end-users

Alex Waibel | Professor

- Speech-to-Speech Translation
- Neural Network / Deep Learning and Language Processing
- Machine Learning
- Machine Translation
- Speech Processing
- Multimodal and Multimedia
Chenyan Xiong  |  Associate Professor

**Speech Recognition and Understanding in Adverse Environments**
- Far-field speech recognition
- Multi-speaker speech recognition
- Speaker diarization
- Speech enhancement and separation
- Audio scene analysis

**Deep Learning for Audio, Speech, and Language Processing**
- End-to-end speech recognition, speech synthesis, and speech translation
- End-to-end integration of audio, speech, and language processing modules

Sean Welleck  |  Assistant Professor

**Machine Learning for Language Technologies**
- Large language models
- Inference algorithms
- Learning algorithms
- Reasoning

**AI for Science**
- Machine learning and mathematics
- Machine learning and formal verification

Yiming Yang  |  Professor

**Graph-based Machine Learning**
- Frameworks and algorithms for prediction and reasoning over heterogeneous graphical data and related text

**Scalable Spatiotemporal Modeling**
- Developing neural network algorithms/architectures for leveraging short/long and multi-granularity dependence structures for time series analysis, event modeling and trajectory prediction

**Extreme-scale Text Categorization**
- Developing state-of-the-art algorithms for document classification against millions of categories with predefined or automatically induced hierarchies or graphical dependency structures
Keywords and Areas of Research

- **Natural Language Processing**
  - Natural Language Analysis (Syntax / Semantic / Pragmatic Analysis) (Fahlman, Fried, Levin, Mitamura, Neubig, Rose)
  - Question Answering (Mitamura, Neubig, Nyberg)
  - Natural Language Generation (Fahlman, Fried, Ippolito, Mitamura)
  - Conversational AI, Intelligent Agents, and Dialogue (Bigham, Bisk, Fried, Nyberg, Rose, Rudnicky, Sap, Wantanabe)
  - Efficient NLP (Neubig, Strubell)
  - Multilingual NLP (Brown, Frederking, Levin, Mortensen, Neubig, Singh, Waibel)
  - Machine Translation (Brown, Frederking, Levin, Mortensen, Neubig, Waibel)
  - Information Extraction (Frederking, Mitamura, Mortensen, Neubig, Rose, Strubell)
  - Symbolic Knowledge Representation and Reasoning (Fahlman, Levin, Rose, Strubell)
  - Fairness and Ethics in Language Technology (Diaz)
  - Creativity (Diaz, Ippolito)
  - Evaluation (Diaz)

- **Computational Linguistics**
  - Morphology and Phonology (Levin, Mortensen)
  - Morphosyntax and Syntax (Levin, Mortensen)
  - Semantics (Fahlman, Mitamura)
  - Discourse and Pragmatics (Frederking, Rose, Sap)
  - Sociolinguistics (Rose)
  - Language Change (Mortensen)

- **Speech Processing (ASR, Speech Synthesis)**
  - Speech Recognition (Raj, Rudnicky, Singh, Waibel, Wantanabe)
  - Speech Synthesis (Waibel, Wantanabe)
  - Multilingual/Low-Resource Speech Processing (Brown, Frederking, Levin, Mortensen, Singh, Waibel, Wantanabe)
  - Speech-to-Speech Translation (Frederking, Waibel, Wantanabe)
  - Speech Forensics (Raj, Singh)
  - Speech Enhancement / Robust Speech Processing (Raj, Singh, Wantanabe)

- **Multimodal Learning**
  - Multimodal AI (Bisk, Fried, Hauptmann, Morency, Rose, Rudnicky, Singh, Waibel)
  - Multimedia analysis (Hauptmann, Rudnicky, Waibel)
  - Language + Vision (Bisk, Fried, Morency, Singh)
  - Affective Computing (Morency, Singh)
  - RoboNLP / Embodied AI (Bisk, Fried, Rudnicky)

- **Information Retrieval** (Diaz, Callan, Nyberg)
  - Recommender Systems (Diaz)
  - Retrieval and Ranking Models (Diaz)

- **Machine Learning for Language Technologies**
  - Graph-based Machine Learning (Yang)
  - Neural Network Algorithms (e.g., XL-Net, DARTS, etc.) (Fahlman, Neubig, Raj, Rose, Strubell, Waibel, Yang)
  - Time Series, Spatiotemporal Modeling (Rose, Shamos, Yang)
  - Query-driven Graph Generation for Causality Analysis (Yang)
  - Extreme-scale Text Classification (Yang)
  - Language Technology Application Areas/Issues (Bigham, Ippolito, Mitamura, Nyberg, Shamos, Strubell, Yang)
  - Privacy and Security (Ippolito, Raj, Shamos)
Keywords and Areas of Research (Cont.)

- Computational Social Science (Rose, Sap)
- Language Technology in Healthcare and Mental Health (Bigham, Hauptmann, Morency, Rose, Singh)
- Language Technology in Education (Mitamura, Rose)
- Fairness and Ethics in Language Technology (Sap, Strubell)
- Interpretability and Explainability in Language Technology (Rose)

- KNOWLEDGE-BASED AI (Fahlman)
  - Symbolic knowledge representation and reasoning
  - Natural-language understanding and generation
  - Knowledge-driven hierarchical planning