



# Language Technologies Institute

## Faculty Research Areas

**Carnegie Mellon University**  
School of Computer Science



## Jeff Bigham | 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 tip of the tongue 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

### GROUNDING 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 SOCIOLOGICALS

- 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



## Michael Shamos | Distinguished Career Professor & Director, MSAIL program



### 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





## Shinji Watanabe | Associate Professor

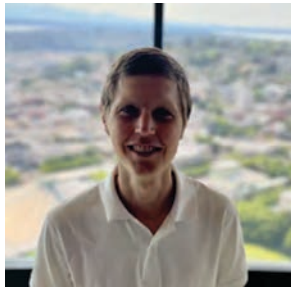
### SPEECH RECOGNITION AND UNDERSTANDING IN ADVERSE ENVIRONMENTS

- 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



## Chenyan Xiong | Associate Professor

### FOUNDATIONAL MODELS FOR INFORMATIONAL RETRIEVAL

- Learn representation space that captures the information from data and matches it with user information needs/interests
- Building next-gen information scenarios with large language models



### EFFICIENT LANGUAGE MODELS

- New pre-training strategies for more effective and efficient scaling of language models
- Efficient neural architectures for large language models

### WEB + LARGE LANGUAGE MODELS

- Augment Language Models with information from the web
- Enable language models to learn and operate directly in the web



## 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, Fried, Rose, Sap*)
  - Sociolinguistics (*Rose*)
  - Language Change (*Mortensen*)
- **SPEECH PROCESSING (ASR, SPEECH SYNTHESIS)**
  - Speech Recognition (*Raj, Rudnicky, Singh, Waibel, Watanabe*)
  - Speech Synthesis (*Waibel, Wantanabe*)
  - Multilingual/Low-Resource Speech Processing (*Brown, Frederking, Levin, Mortensen, Singh, Waibel, Watanabe*)
  - Speech-to-Speech Translation (*Frederking, Waibel, Watanabe*)
  - 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