MULTIMODAL PROBABILISTIC LEARNING OF HUMAN COMMUNICATION

(SUBJECT TO CHANGE - this is not final)

Time: Tuesday & Thursday 3:30-5:20
Classroom: KAP 145 and/or virtual (to be determined)
Instructor:
Professor Mohammad Soleymani, soleymani@ict.usc.edu
TA: TBH
Office: ICT 338 (by appointment only)

Recommended preparation: CSCI 567 CSCI 561 or CSCI 566 or equivalent. Students should have a proper academic background in probability, statistics and linear algebra. Previous experience in machine learning is suggested but not obligatory. This course is not a replacement for the Machine Learning course (CSCI 567).

Introduction and Purposes

Human face-to-face communication is a little like a dance, in that participants continuously adjust their behaviors based on verbal and nonverbal displays and signals. Human interpersonal behaviors have long been studied in linguistic, communication, sociology and psychology. The recent advances in machine learning, pattern recognition and signal processing enabled a new generation of computational tools to analyze, recognize and predict human communication behaviors during social interactions. This new research direction has broad applicability, including the improvement of human behavior recognition, the synthesis of natural animations for robots and virtual humans, the development of intelligent tutoring systems, and the diagnoses of social disorders (e.g., autism spectrum disorder).

The objectives of this course are:

1. To give a general overview of human communicative and social behaviors (language, vocal and nonverbal) and show a parallel with computer science (natural language processing, speech processing and computer vision);
2. To understand the multimodal challenge of human communication (e.g. speech and gesture synchrony) and learn about multimodal signal processing;
3. To understand the social aspect of human communication and its implication on computational modeling;
4. To learn about recent advances in machine learning and pattern recognition to analyze, recognize and predict human social and communicative behaviors;
5. To give students practical experience in computational study of human social communication through a course project.
Course format

Course includes lectures, discussion, assignments and a project. There will be a total of three assignments which will be done individually. Each student will also present one relevant paper and lead the discussion on the topic. Students will be asked to form teams (up to three people) and present their project advancement for mid-term and at the end of the semester.

Course Material

Required:
Reading material will be based on published technical papers available via the ACM/IEEE/Springer digital libraries or freely available online. All USC students have automatic access to these digital archives.
Python, MATLAB can be used using USC license (for practical exercises)

Optional:

- *Nonverbal Communication in Human Interaction (7th edition)*, Mark Knapp and Judith Hall, Wadsworth, 2010
- *Speech and Language Processing (2nd edition)*, Daniel Jurafsky and James Martin, Pearson, 2008

Course Topics and Readings

** Topics and readings may change based on student interest **

Lectures
(Tue/Thu 3:30-5:20pm)

**Week 1**
Introduction and communication models
- Human communication dynamics
- Applications and domains
- Communication models
- Mid-term and final projects
- Datasets and sensing tools

Reading material
- Vinciarelli et al. (2012), Social Signal Processing
• Krauss et al. (2002), The psychology of Verbal Communication
• (optional) Pentland (2008), Honest Signals, Ch. 1
• (optional) Morency et al. (2010), Human Communication dynamics

**Week 2**

Machine Learning: basic concepts
• Classification and Evaluation methods
• Training/validation and testing
• Decision models
• Support Vector Machine
• Neural networks/deep learning
• CNNs and RNNs
• ML toolbox (scikit-learn)

Reading material
• (optional) https://github.com/jakevdp/sklearn_tutorial
• Courville et al., 2015 deep learning (optional)
• (optional) Langley and Kibler (1991), The Experimental Study of Machine Learning

**Week 3**

**Draft project proposals due**

Study Design, Evaluation and Analysis
User studies (guest lecture by Gale Lucas - to be confirmed)
• Coder agreement, kappa
• Statistical analysis
• Student t-test, effect-size

Reading material
• Lucas et al. (2014), It's only a computer: Virtual humans increase willingness to disclose
• Costa et al., CHI 2018. Regulating Feelings During Interpersonal Conflicts by Changing Voice Self-perception
• (optional) Wainer (1984) - How to display data badly - The American Statistician
• (optional) Leroy (2011), Designing User Studies in Informatics

**Week 4**

Project proposal presentations (Flash talks – 5m +5m Q&A)
Affective messages and personality traits
• Emotion theory
• Social emotions
• Social behaviors
- Big five personality dimensions

**Reading material**
- de Melo et al. (2013). Reading People’s Minds: From Emotion Expressions in Interdependent Decision Making
- (optional) Gratch et al. (2013), Felt emotion and social context determine the intensity of smiles in a competitive video game
- (optional) Gratch and Marsella (2005), Emotion Psychology
- (optional) Barrick and Mount (1991), Big Five personality

**Week 5**
**Vocal messages**
- Phonetics and phonology
- Prosody and voice quality
- Vocal expressions
- Audio representation and basic feature extraction
- Praat/OpenSMILE

**Reading material**
- Schuller et al., (2011), Recognising realistic emotions and affect in speech: State of the art and lessons ..
- (Optional) Eyben et al. (2015), The Geneva Minimalistic Acoustic Parameter Set (GeMAPS) for Voice Research …
- (optional) Bachorowsky et al. (2001), The acoustic features of laughter
- (optional) Ladefoged (2004), A course in phonetics

**Week 6**

**Virtual Humans**
- VHToolkit (Guest lecture by Arno Hartholt)
  - Behavior planning and generation
- Multimodal behavior generation
- Designing ECAs

**Reading material**
- Devault et al. Simsensei 2014
- (optional) Ding et al. (2014) Laughter Animation Synthesis

**Week 7**
Verbal and Conversational messages
- Discourse analysis
- Turn-taking and backchannel
- Semantics and pragmatics
- Speech and dialogue acts
- Language models and N-grams
- Boundaries, fillers and disfluencies
- Syntax and part-of-speech tagging
- Word and sentence embedding (GloVe, BERT, etc.)

Reading material
- Ghosh et al. Affect-LM:, ACL 2017
- (optional) Hoegen et al. Conversational style, 2019
- (optional) Stolcke et al. CL 2000: Dialogue act modeling for automatic tagging and...
- (optional) Bohus and Horvitz (2010), Computational Turn-taking
- (optional) Jurafsky and Martin (2008), Speech and Language Processing, 4.1-4.4, 5.1-5.3 and 12.1-12.2
- (optional) Liu et al. (2004) Metadata extraction
- (optional) Clark and Brennan (1991)

Week 8
Multimodal behavior recognition (1/2)
- Multimodal fusion
- Multimodal alignment,
- Audio-visual recognition
- Long Short-term Memory Networks

Reading material
- Baltrušaitis et al., 2018
- (optional) Kang et al, 2010
- (optional) Soleymani et al, 2019

Week 9
Human-Robot communication
Guest lecture by Stefanos Nikolaidis (to be confirmed)
Lecture on Social robotics

Reading material
- Celiktutan et al. Computational Analysis of Affect, Personality, and Engagement in Human–Robot Interactions, 2018
- Dong et al., Embodiment in socially interactive robots, 2019
Week 10
(31 Mar, 2 Apr)
Mid-term project presentations (mid-term reports are due) (report deadline April 3rd)

Week 11
Multimodal behavior recognition (2/2)
- Gaze in interaction
- Speech activity detection
- Guest lecture by Kalin Sefanov

Multimodal behavior recognition (2/2)
- (optional) Stefanov et al, 2019

Week 12
Multimodal Sentiment Analysis
- Sentiment vs emotions
- Text-based sentiment analysis
- Multimodal sentiment analysis

Health
- Multimodal behavior analysis in Health
- Mental health assessment
- Neurodevelopmental disorders
- Neurodegenerative disorders

Reading material - sentiment
- Pang et al. EMNLP 2002: Thumbs up? Sentiment classification using machine learning techniques
- Soleymani et al. 2017, definition
- Tavabi et al, 2019
- Zadeh et al, 2017

Reading material - health
- Tavabi et al., 2020
- Cummings et al, 2015
Week 13

**Dyadic and Multiparty Interactions**
- Dyadic Modeling
- Recurrence plot analysis
- Synchrony and entrainment
- Team processes and assessment
- Climate and cohesion
- Knowledge formation

**Bias and ethics**
- Bias
- Fairness

**Dyadic and Multiparty Interactions**
**Team processes and assessment**
- Kozlowski
- Neubauer et al. 2016
- Zhang et al. 2018

**Bias and ethics**
- Raghavan et al., 2019
- McDuff et al., 2019
- Yan et al., 2020

Week 14

Final project presentations

---

**Bibliography**

**Primary readings**

**Introduction and communication models**


4. (optional) Pentland, Honest Signals, Chapter 1

Machine Learning: Basic Concepts


**Study Design, Evaluation and Analysis**


10. (optional) H Wainer - How to display data badly - The American Statistician, 1984


**Affective messages and personality traits**


**Vocal messages**


20. (Optional) Ladefoged (2004), A course in phonetics

**Visual messages**


24. (optional) Adam Kendon, An Agenda for Gesture Studies, This article appeared in Volume 7 (3) of the Semiotic Review of Books.


**Virtual humans**


**Verbal messages**


31. (optional) Jurafsky and Martin (2008), *Speech and Language Processing*, Sections 4.1-4.4, 5.1-5.3 and 12.1-12.2


**Conversational messages**


35. Duncan (1974) *Some Signals and Rules for Taking Speaking Turns in Conversations*

Multimodal behavior recognition (1/3)

41. Baltrušaitis, Tadas, Chaitanya Ahuja, and Louis-Philippe Morency. "Multimodal machine
learning: A survey and taxonomy." IEEE Transactions on Pattern Analysis and Machine

42. I. McCowan, D. Gatica-Perez, S. Bengio, G. Lathoud, M. Barnard, M., D. Zhang,
"Automatic analysis of multimodal group actions in meetings", IEEE Transaction on
Pattern Analysis and Machine Intelligence, Vol. 27, pp. 305–317, 2005

Social robotics

45. Celiktutan, Oya, Evangelos Sariyanidi, and Hatice Gunes. "Computational Analysis of
Affect, Personality, and Engagement in Human–Robot Interactions." Computer Vision for

Multimodal behavior recognition 2/3 (gaze, gesture and speech activity)

47. (optional) K. Stefanov and J. Beskow, "A real-time gesture recognition system for isolated

48. (optional) K. Stefanov, G. Salvi, D. Kontogiorgos, H. Kjellström and J. Beskow, "Modeling of
human visual attention in multiparty open-world dialogues," in ACM Transactions on
Human-Robot Interaction, 2019.


53. (optional) S. Rautaray and A. Anupam, "Vision based hand gesture recognition for human
Multimodal behavior recognition (3/3) Health and Sentiment


Dyadic and team processes


Bias and ethics


Health


Grades

Grading breakdown

- Attendance and participation (10%)
- Three practical exercises 30% (10% each)
- One paper discussion moderation (10%)
- Course project:
  - § Mid-term project report and presentation 15%
  - § Final report and presentation 35%

Attendance

- Students are expected to attend every class (1 free absence allowed) and participate actively during the discussions.

Paper discussion
Students are expected to choose one paper (a non-exclusive list will be given), briefly present it to the class and lead the discussions on it.

Assignments
- These three assignments will be designed to give hands-on experience with multimodal data analysis and machine learning (e.g., SVM, neural networks) for multimodal behavior recognition.
- Each assignment will come with sample code (Python) and links to existing machine learning libraries.
- Students will need to submit their code (zip files) with their answer to each practical exercise.

Course project:
- The goal of this course is to analyze human communicative behaviors in social settings using state-of-the-art statistical and probabilistic models. The course project is specifically designed to give students practical experience in computational study of human social communication.
- Students can perform the project individually or in a team of up to three. The mid-term and final report will need to outline the tasks of each participant. Team projects will be expected to include a deeper analysis than individual projects.
- Mid-term report: The mid-term report will present a qualitative analysis of the selected dataset and communicative behaviors. The report should include correct transcription and annotations of the language, vocal and nonverbal behaviors. Using standard statistical tools and qualitative observations, the students should highlight the challenges with this dataset (and communicative behaviors) and suggest an approach to solve them.
- Final report and presentation: Using the same dataset as the mid-term report, the final report will include a quantitative analysis of the human communicative behaviors. The final report should be phrase as a research paper describing either a comparative study of different statistical and probabilistic approaches or a new technique for behavior modeling.

Statement for Students with Disabilities
Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

Statement on Academic Integrity
USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation
that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one’s own academic work from misuse by others as well as to avoid using another’s work as one’s own. All students are expected to understand and abide by these principles. Scampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: http://www.usc.edu/dept/publications/SCAMPUS/gov/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/.