Communication Complexity and Applications – Spring 2022
Course Presentation

By now you should have your course topic chosen and set up an appointment with me to discuss. You should prepare your course presentation which may involve slides or blackboard presentation. You should also prepare lecture notes. On the course webpage you will find a template latex file for preparing your lecture notes. Please contact me if you have any other questions.

1 Picking your Topic

Please send me an email or make an appointment by Feb 21, with your proposed topic and paper(s) that you will present. Include in your email who you will be working with or if you plan to work alone. Two people will be expected to cover the topic in more depth, and will have a longer time for the presentation (45-60 minutes for 2 people, 30-45 minutes for one person.) You are welcome to suggest a different topic than those that I list below but if you do so, please come and talk with me.

After your topic is approved, I will give you a date for your presentation. Your presentation may include slides (powerpoint or whatever you choose), and should include lecture notes.

2 Suggestions for Topics/Papers for Presentation

I am not expecting you to read and cover all of the papers within each topic. However I am listing the "original" ones that introduced the connection, and more recent ones. If you think you are interested in a topic but need help navigating through the literature (to pick one or two papers to focus on) please come and talk with me. I would expect that you would understand a bit about the basic connection and then also cover a more recent paper on the topic.

Overall good resources for many of these topics are: The original Kushilevitz/Nisan book on Communication Complexity, Tim Roughgarden's notes called Communication Complexity (for Algorithm Designers), and the Communication Complexity textbook by Rao and Yehudayoff. You may also want to look at previous versions of this course that I have taught at U Toronto, and look at some of the student presentations from those years.

The survey article called The Story of Set Disjointness (by Chattopadhyay and Pitassi) also includes a lot of applications and references.

(1.) The log-rank conjecture.

Shachar Lovett Recent Advances on the Log Rank Conjecture, Bulletin of EATCS 2014.

Gavinsky, Lovett En Route to the log-rank Conjecture: New Reductions and Equivalent Formulations

Nisan, Wigderson. On Rank vs Communication Complexity

Ben-Sasson, Lovett, Zewi. An additive combinatorics approach to the log-rank conjecture

Shahar Lovett. Communication is bounded by root of rank. STOC 2014.

Thomas Rothvoss. A direct proof for Lovett's bound on the communication complexity of low rank matrices. arXiv.org

(2.) Communication Complexity and Data Structures.

Video Lecture (by Kasper Larson) Communication Complexity and Data Structures https://www.birs.ca/events/2014/5-day-workshops/14w5164/videos

Miltersen. Cell Probe Complexity - A Survey. In Advances in Data Strutures, 1999.

Miltersen, Nisan, Safra, Wigderson. On data structures and asymmetric communication complexity. JCSS 1998.

Mihai Patrascu. "Towards Polynomial Lower Bounds for Dynamic Problems"

Patrascu. Unifying the Landscape of Cell Probe Lower Bounds. FOCS 2008.

Chattopadhyay, Edmonds, Ellen, Pitassi. "A little advice can be very helpful." Soda, 2011 Video lecture on this paper by Arkadev Chattopadhyay https://www.birs.ca/events/2014/5-day-workshops/14w5164/videos

See also Tim Roughgarden's notes.

(3.) Communication Complexity and Distributed Computing

Video Lecture by Rotem Oshman The Role of Communication COmplexity in Distributed Computing https://www.birs.ca/events/2014/5-day-workshops/14w5164/videos

Braverman, Ellen, Oshman, Pitassi, Vaikuntanathan Tight bounds for set disjointness in the Message Passing Model

Chattopadhyay, Radhakrishnan, Rudra Topology Matters in Communication, ECCC tech report, also to appear in FOCS 2014.

See also Rao and Yehudayoff chapter on distributed computing.

(4.) Communication Complexity and Proof Complexity

Goos, Pitassi Communication Lower Bounds via Critical Block Sensitivity arXiv.org

(5.) Communication Complexity and Extended Formulations

Tutorial on the subject: http://people.csail.mit.edu/moitra/docs/tutorialf.pdf

Video talks by Prasad Raghavandra:

https://www.birs.ca/events/2013/5-day-workshops/13w5010/videos

https://www.birs.ca/events/2014/5-day-workshops/14w5051/videos

Fiorini, Massar, Pokutta, Tiwary, deWolf Linear vs semidefinite extended formulations: exponential separation and strong lower bounds, Stoc 2012

Thomas Rothvoss The matching polytope has exponential extension complexity, STOC 2014.

Braun, Fiorini, Pokutta, Steurer Approximation Limits of Linear Programs (Beyond Hierarchies)

(6.) Communication Complexity and Circuit Depth Lower Bounds

Karchmer, Wigderson Monotone circuits for connectivity require superlogarithmic depth

Goos, Pitassi Communication Lower Bounds via Critical Block Sensitivity

(7.) Communication Complexity and Streaming

Video Lecture by David Woodruff Lower Bounds for Data Streams https://www.birs.ca/events/2014/5-day-workshops/14w5164/videos

Alon, Matias, Szegedy. The Space Complexity of Approximating the Frequency Moments, STOC 1996.

See also Tim Roughgarden's Lecture Notes "Communication Complexity (for Algorithm Designers)."

(8.) Communication Complexity and Game Theory

See Tim Roughgarden's Notes "Communication Complexity (for Algorithm Designers)." The last section of the following survey article also gives a brief overview of several applications of communication complexity in game theory.

Chattopadhyay, Pitassi The Story of Set Disjointness.

Another application (which is fairly easy once you have BPP lifting) is game theory. A nice presentation would be to state the lower bound as in this paper, but give the easier proof using BPP lifting theorem.

(9.) Communication Complexity and Property Testing

Video Lecture by Joshua Brody Property Testing Lower Bounds via Communication Complexity https://www.birs.ca/events/2014/5-day-workshops/14w5164/videos

See also Tim Roughgarden's Lecture notes "Communication Complexity (for Algorithm Designers)."

(10.) Information Complexity

This is a rather large recent topic. Here are some papers although there are really a lot of papers on this subject! The book by Rao and Yehudayoff should be a great reference for this subject.

Mark Braverman and Anup Rao. "Information Equals Amortized Communication."

Mark Braverman. "Interactive information complexity." STOC 2012.

Amit Chakrabarti, Yaoyun Shi, Anthony Wirth, and Andrew Yao. "Information Complexity and the Direct Sum Problem for Simultaneous Message Complexity." FOCS 2001.

Ziv Bar-Yossef, T. S. Jayram, Ravi Kumar, and D. Sivakumar. "An information statistics approach to data stream and communication complexity." Journal of Computer and System Sciences, Volume 68, p. 702-732, June 2004.

(11.) The Gap Hamming Problem Sherstov, A. "The communication complexity of gap Hamming distance."

(12.) Lower Bounds for Unbounded Error Communication Complexity (Forster's theorem) and connections to Paulson problem.

Forster. A linear lower bound on the unbounded error probabilistic comm complexity JCSS.

Sherstov. The unbounded error Communication Cmplexity of Symmetric Functions

Paulson problem: Hamilton, Moitra. "The Paulson Problem Made Simple." https://arxiv.org/abs/1809.04726

Great survey article on Paulson problem and radial isotropy. Artstein-Avidan, Kaplan and Sharir. "On Radial Isotropic Position: Theory and Algorithms." https://arxiv.org/abs/2005.04918

(13.) Lower Bounds in Learning via Communication Complexity

Gollakota, Karmalkar, Klivans. "The Polynomial Method is Universal for Distribution-Free Correlational SQ Learning. " https://arxiv.org/pdf/2010.11925v1.pdf

(14.) Lower Bounds for Compressive Sensing. See Tim Roughgarden's notes "Communication Complexity (for Algorithm Designers)" for an overview and for the original references.

(15.) Quantum Lower Bounds via Communication Complexity

See these course notes by Shalev Ben-David: https://cs.uwaterloo.ca/ s4bendav/CS860S20.html

(16.) Clique/CoClique problem and connections to Learning, and the Alon-Saks-Seymour Graph theory conjecture.

Original paper by Goos giving lower bound for Clique/Coclique, and disproof of ASS conjecture. Plus a beautifully simple application of this lower bound, showing that it can be more difficult to learn partial functions than total functions.

Goos. Lower Bounds for Clique versus Independent Set https://eccc.weizmann.ac.il/report/2015/

Balodis, Ben-David, Goos, Jain, Kothari. Unambiguous DNFs and Alon-Saks-Seymour https://eccc.weizmann.ac.il/report/2021/016/

Alon, Hanneke, Holzman, Moran. A theory of PAC learnability of partial concept classes https://arxiv.org/abs/2107.08444

(17.) Privacy and Communication Complexity

Differential Privacy: McGregor, Mironov, Pitassi, Reingold, Talwar, Vadhan. The Limits of Two Party Differential Privacy.

Differentially Private Learning: Lots of papers on this by Vitaly Feldman including this one. Feldman, Xiao. Sample Complexity Bounds on Differentially Private Learning via Communication Complexity. https://arxiv.org/abs/1402.6278

(18.) Lifting in Communication Complexity

Deterministic Lifting: Raz, McKenzie. Separation of the Monotone NC Hierarchy.

Goos, Pitassi, Watson. "Deterministic Communication versus Partition Number." https://eccc.weizmann.ac.il/report/2015/050/

Randomized Lifting: Goos, Pitassi, Watson. Query to Communication Lifting for BPP. https://eccc.weizmann.ac.il/report/2017/053/

Lifting and connection to Sunflower Lemma in Combinatorics: Lovett, Meka, Mertz, Pitassi, Zhang. Lifting with Sunflowers.

(19.) Multiparty NOF Communication Complexity and Applications.

Original paper: Babai, Nisan and Szegedy. Multiparty protocols and logspace-hard pseudorandom sequences.

Nice lecture notes (and connections to additive combinatorics and other problems) by Shachar Lovett. https://cseweb.ucsd.edu/classes/wi19/cse291-b/5-multiparty.pdf

Separating randomized from nondeterministic: https://www.cs.toronto.edu/ toni/Papers/random multicc.pdf

Communication Complexity and Additive Combinatorics: https://drops.dagstuhl.de/opus/volltex ITCS-2019-54.pdf https://drops.dagstuhl.de/opus/volltexte/2021/14276/pdf/LIPIcs-CCC-2021-2.pdf

There is also this classic result showing that strong enough NOF lower bounds imply unconditional lower bounds for the circuit class ACC:

(20.) Interactive communication with noise.

The seminal work of Schulman studied communication complexity across a noisy broadcase channel, where bits are corrupted, and he gives a coding scheme that is efficient. That is, a general way of converting a noiseless protocol into another protocol (that doesn't cost too much in overhead) that is resilient to a certain amount of noise. The original paper is here:

http://authors.library.caltech.edu/29884/1/SCHUfocs92.pdf

Since then there have been many papers and extensions to this basic work. Here is a good survey article: https://www.eng.biu.ac.il/ gellesr/survey.pdf

Here are some lecture notes by Madhu Sudan on the basic construction of tree codes that are resilient to errors. https://people.seas.harvard.edu/ madhusudan/courses/Spring2020/notes/L24.pdf See also the scribe notes from lecture 24 here (v1 and v2) https://people.seas.harvard.edu/ madhusudan/courses/Spring2020/