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Research Proposal

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In this research proposal, I list out 3 possible directions that I'm interested in. Nevertheless, I'm still open-minded and look forward to any discussion with Professors and classmates from University of Edinburgh.

Network Coding for URLLC

Recently I find MIT Professor Muriel Medard's works about network coding are very interesting. Specifically, they proposed "GRAND" in notable papers like "Capacity-Achieving Guessing Random Additive Noise Decoding" and "Guessing Noise, Not Code-words". In these works they introduce new algorithms for Maximum Likelihood (ML) decoding for channels with memory based on the principle that the receiver rank orders noise sequences from most likely to least likely. Subtracting noise from the received signal in that order, the first instance that results in an element of the code-book is the ML decoding. In contrast to traditional approaches, this novel scheme has the desirable property that it becomes more efficient as the code-book rate increases. When the code-book rate is less than capacity, we can identify asymptotic error exponents as the block-length becomes large. On the other hand, when the code-book rate is beyond capacity, we can identify asymptotic success exponents. Beyond "guessing noise", network coding, as the third dimension other than source coding and channel coding in information coding, may be a fruitful field for these kind of algorithms to work. However, while my recent work about stochastic scheduling of industrial wireless sensor networks take place as the intersection of wireless communication and information theory, I cannot say that I'm familiar with network coding. Thus, it gives a strong reason for me to dive into this certain field during my graduate study at University of Edinburgh.

Calibrated Forecasting

When a forecaster says that it will rain tomorrow, it is easy to verify whether the forecast is correct, by waiting until the next day and seeing whether it rains or not. But when a forecaster says that there is a 30% chance of rain tomorrow, what does that really mean? And how could we verify whether the forecast is correct? In terms of mathematical philosophy, the definition of calibration adopts a frequentist approach to judging the correctness of a sequence of forecasts, while strictly proper scoring rules adopt a Bayesian approach. We don't live in a probability space where we can examine all "possible worlds" and check what fraction of the possible worlds experience rain tomorrow. So how could we judge if such a probabilistic prediction was really correct or not? Is it even meaningful to ask whether the forecast was correct? Two possible answers to this question start from the notion that it's impossible to judge whether a single probabilistic prediction is correct, but that it might be possible to approximately judge the correctness of a sequence of predictions. One way to do this is to require that the sequence of predictions be calibrated, meaning that if one looks at all the forecasts which were close to some distribution p, the actual distribution of outcomes observed at those times is also close to p. A second way of judging the correctness of a sequence of predictions is to assign a score to each prediction using a function which ensures that correct probabilistic predictions outscore incorrect predictions, in expectation. Such functions are called strictly proper scoring rules. Over a sequence of many predictions, a forecaster who is outputting correct probabilities will almost surely outscore a forecaster who is outputting incorrect probabilities, by the law of large numbers. This is also a topic that I'm interested in, more attractive is that "prediction methods" can be applied to almost every field of study.

Privacy-Preserving Decision Schemes

"The future is already here — It's just not very evenly distributed." Research for decentralizing the internet is an important issue nowadays since the power of tech giants is so strong that they can even violate moral principles to exploit people's rights. I'd also like to work on privacy-preserving optimization problems for balancing the power between network application users and service providers from different tiers. For instance, to deal with the modern COVID-19 pandemic, the government decides to deploy a surveillance system by mobile phones and internet-of-thing (IoT) devices. With the help of these systems, policies like regional lockdown can be decided much more properly, instantly, and with heterogeneity compared to

commonly used compartmental models like SIR. However, personal information, mobility data and medical data should be organized with high regularization. It shouldn't be sold by companies and government organizations, nor should be taken by internet service providers. Although not having direct access to some data, how these stakeholders collaborate is the problem we'd like to solve. The problem should be formulated in the form of mathematics as a mathematical optimization problem or a game, for deciding the policies and strategies that should be taken by each player. I believe these kinds of problems are very practical while there are still plenty of rooms for us to conduct innovative research.

Prospect

The research experiences I gained during my master's studies were invaluable and strengthened my resolution to keep delving into the field of networks and systems. While conducting research would be the main focus during my graduate years, my career goal as aforementioned is more than just research alone. By joining University of Edinburgh, I would be provided with the opportunity to work with diverse people across various disciplines and advance the skills I need. Overall, by seeking admission into the MSc by Research Engineering and Electronics (Digital Communications) program at University of Edinburgh, I will keep pushing myself to be a researcher that demonstrates expertise in the realms of networks and systems while at the same time developing excellent communication and leadership skills. At the end of my study, I will possess the ability to combine theory and practice along with the personality traits that would help me pave an avenue towards becoming a tech billionaire. At last, I'd like to show my appreciation for you to read my research proposal.

Sincerely, Chi-Jen Lo, Dec 2020