

Part I – Contributions to research and development

c. Papers in peer-reviewed conference proceedings

- Ashtiani, Hassan, **Kushagra, Shrinu**, and Shai Ben-David. "Clustering with same-cluster queries." In Advances in Neural Information Processing Systems, 2016 (To appear).
Oral presentation (46 accepted out of 2500 submissions). Work done during doctoral degree.
- **Kushagra, Shrinu**, Samadi, Samira and Shai Ben-David. "Finding meaningful cluster structure amidst background noise." In International Conference on Algorithmic Learning Theory, pp. 339-354, 2016.
Oral presentation. International conference. Work done during doctoral degree.
- **Kushagra, Shrinu**, and Shai Ben-David. "Information Preserving Dimensionality Reduction." In International Conference on Algorithmic Learning Theory, pp. 239-253. Springer International Publishing, 2015.
Oral presentation. International conference. Work done during the completion of master's degree.
- **Kushagra, Shrinu**, Alejandro Lopez-Ortiz, J. Ian Munro, and Aurick Qiao. "Multi-pivot quicksort: Theory and experiments." In Proceedings of the Meeting on Algorithm Engineering & Experiments, pp. 47-60. Society for Industrial and Applied Mathematics, 2014.
Oral presentation. International conference. Work done during the completion of master's degree.
- Ji, Xiang*, **Shrinu Kushagra**, and Jeff Orchard. "Sensory updates to combat path-integration drift." In Canadian Conference on Artificial Intelligence, pp. 263-270. Springer Berlin Heidelberg, 2013.
Poster presentation. International conference. Work done during the completion of master's degree.

Part II – Most significant contributions to research and development

Clustering with same-cluster queries

- I was one of the main contributors of this project both in terms of research contribution and technical writing. I wrote the first draft of the manuscript which was later edited by my coauthors Shai Ben-David and Mr. Hassan Ashtiani.
- The project had two major components. The first one involved designing an algorithm and proving that it works when our input satisfies certain conditions. This result was obtained with active collaboration with my coauthor Mr. Ashtiani. The second part was much more challenging. This involved proving that if the conditions are not satisfied then no algorithm can find the solution in a reasonable amount of time. This direction, including the proof, was mainly investigated by me.
- This work will appear in Neural Information Processing Systems, NIPS 2016. It has been accepted for an oral presentation. NIPS is one of the best conferences in Machine Learning. This year around 2500 submissions were made. Out of those only 46 were accepted for an oral presentation. The submission was reviewed by six anonymous reviewers.
- We prove that the task of clustering is computationally expensive. However, with the help of weak human supervision, we can transform this computationally expensive task into an easy one. The result is highly encouraging and surprising and very few such results are known in the computer science literature. One of the reviewers even remarked that "Novelty/originality of the work, theory, algorithm and applications are ground-breaking and potentially seminal".

Finding meaningful cluster structure amidst background noise

- I was one of the main contributors of this project both in terms of research contribution and technical writing. I wrote the first draft of the manuscript which was later edited by my coauthors Shai Ben-David and Ms. Samira Samadi.
- This work will appear in Algorithmic Learning Theory, ALT 2016. It has been accepted for an oral presentation. ALT is one of the top-tier conferences in Theoretical Machine Learning and the submission was reviewed by three anonymous reviewers.

- In this work, we introduced a novel notion to capture noise in realistic datasets. We introduce efficient algorithms that discover and cluster every subset of the data with meaningful structure. We further show that when either the notions of structure or the noise requirements are relaxed, no such results are possible. I was the principal investigator on all the research directions of this project.
- This work lays the theoretical foundation for clustering under reasonable assumptions on data.

Multi-pivot quicksort: Theory and experiments

- I and Mr. Auckrick Qiao were the main contributors on this project both in terms of research contribution and technical writing. The first draft was jointly written by us. This was later edited by my other coauthors Ian Munro and Alex Ortiz.
- This work appeared in Algorithm Engineering and Experiments, ALENEX 2014 as an oral presentation. Quicksort is a classical algorithm for sorting a list of numbers. Up until about a decade ago, it was thought that the classic quicksort algorithm is superior to any multi-pivot scheme. However, in 2009 a dual-pivot algorithm was proposed which outperformed the standard algorithm. We proposed a three-pivot quicksort variant. We proved, theoretically and experimentally that our algorithm has better performance than other schemes. While me and my coauthor auckrick qiao actively collaborated to obtain the experimental evaluations, the theoretical results were proved by me.
- Since its publication, this work has been cited 20 times. The algorithm has also been introduced into first year computer science courses at Princeton university. The algorithm and methods developed in this work have also been discussed in graduate seminar courses at Stanford University.

Part III – Applicant’s statement

Research Experience

My research experiences have already been documented in the previous two sections and reflected in my publication record. The diverse projects have helped me gain an ability to think critically and reason about any problem. Besides research, I have had an opportunity to work in the software industry. From May to Aug 2016, I was a software intern at Pinterest. Pinterest is an online discovery engine helping its users discover new ideas. As of Sept 2016, it had 50 million weekly active users and a revenue of \$400 million.

As an intern on the ads ranking team, my job was to develop algorithms so as to display more relevant ads to the users. This experience helped me gain very useful insight into how the algorithms that we develop as researchers are actually used in practice. One of the approaches was to cluster the users so that similar users are shown similar ads. However, common clustering algorithms like k -means just didn't work. And hence this direction had to be abandoned and a non-clustering approach had to be implemented. This goes to show that more research is needed to incorporate domain knowledge into clustering algorithms, something which one of our current papers (NIPS' 16) aims to achieve.

Relevant activities

I have been on the President's Athletic Academic Honour Roll for the last two years. This award is for students who have shown excellent academic record and proficiency in sports. Being a member of the squash team and maintaining an average well above 90% helped me get this award.

I have been employed by the University of Waterloo as a teaching assistant for the last four years. My duties include helping the professors with assignment marking, course design and mentoring undergraduate students during the weekly office hours.