IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Non-adaptive group testing using sparse regression**	
Project Number	**IMURA0939**	
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Research Clusters:

Research Themes:

Highlight which of the Academy's CLUSTERS this project will address? *(Please nominate JUST **one**. For more information, see www.iitbmonash.org)*		**Highlight which of the Academy's Theme(s) this project will address?** *(Feel free to nominate more than one. For more information, see www.iitbmonash.org)*	
1	*Material Science/Engineering (including Nano, Metallurgy)*	***1***	***Advanced computational engineering, simulation and manufacture***
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*	2	*Infrastructure Engineering*
3	*Math, CFD, Modelling, Manufacturing*	3	*Clean Energy*
4	***CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control***	4	*Water*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*	5	*Nanotechnology*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*	6	*Biotechnology and Stem Cell Research*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*	7	*Humanities and social sciences*
8	*HSS, Design, Management*	8	Design

The research problem

Define the problem

Group testing is an important area of signal processing and information theory, with useful application in saving resources in medical tests. The aim is not to test every individual medical sample sequentially for a given disease, but instead to pool together small but equal portions of different samples and test the pools instead [1]. Typically, the number of pools is less than the number of samples. The aims are:

1) to develop methods to determine which individual sample is positive in the group given the results of the pooled tests.
2) to estimate the specific parameter in each of the individual samples given the results of the pooled tests. When this specific parameter for a given sample exceeds a certain threshold, then the sample is considered positive. For example, in RT-PCR tests for COVID19, this parameter can be the viral load in a sample of saliva or a naso-pharyngeal swab.

Most of the current state of the art group testing algorithms consider binary tests, i.e. a pool as well as any sample are binary in value. However, in this project, we propose to use quantitative values in both the pool and sample, which yields us more information, and to also consider the use of well motivated noise models, such as multiplicative noise (common in RT-PCR testing) and noise induced due to pooling errors or discrepancies between the recorded and actual pool memberships.

The aim is to develop robust, computationally efficient, estimators which take into account these issues, and analyze their performance theoretically as well as experimentally. The proposed scope considers only single-stage or non-adaptive tests [1], which saves on a great deal of testing time as opposed to multi-round or adaptive tests [4]. The aim is to use, and further develop, results and techniques in sparse regression and compressed sensing [2,3], under the realistic assumption that only a small fraction of the samples undergoing tests are positive. Additionally, the project also considers methods to design pooling matrices that would facilitate good quality signal reconstruction, also taking into account various practical application-specific constraints.

References

[1] SabyasachiGhosh, Rishi Agarwal, Mohammad Ali Rehan, ShreyaPathak, PratyushAgarwal, Yash Gupta, Sarthak Consul, Nimay Gupta, RitikaGoyal, *AjitRajwade*, ManojGopalkrishnan, "A Compressed Sensing Approach to Group-testing for COVID-19 Detection", [arxiv report]
[2] T. Hastie, R. Tibshirani, and M. Wainwright, Statistical Learning with Sparsity: The LASSO and Generalizations. CRC Press, 2015.
[3] D. L. Donoho, A. Maleki and A. Montanari, Message-passing algorithms for compressed sensing, PNAS 2009
[4] Matthew Aldridge, Oliver Johnson, Jonathan Scarlett, Group Testing: An Information Theory Perspective, https://arxiv.org/abs/1902.06002

Project aims

Define the aims of the project

1) Design estimators for group testing with results shown on simulated data
2) Theoretical analysis of estimators - upper and lower bounds
3) Algorithms for pooling matrix design

Expected outcomes

Highlight the expected outcomes of the project

A suite of algorithms for group testing, with theoretical analysis of performance

How will the project address the Goals of the above Themes?

Describe how the project will address the goals of one or more of the 6 Themes listed above.

Advanced computational engineering, simulation and manufacture: Group testing is very widely useful in the context of the ongoing pandemic, in order to save resources required for medical testing.

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. Feel free to be as specific or as general as you like. These capabilities will be input into the online application form and students who opt for this project will be required to show that they can demonstrate these capabilities.

Masters degree in Mathematics, statistics, electrical engineering or computer science

Potential Collaborators

Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.

Daniel Schmidt