Abstracts of EIGHT Research Projects in ACMU, ISI with openings for Project-Linked positions

1. Geometric Shortest Path Problems with Violations

Abstract:

In geometric contexts, a shortest path is a path (that is, a continuous image of an interval) of minimum length (under some metric) among all paths that are feasible (that is, satisfying all imposed constraints) in a given geometric domain. In such a geometric domain one may be interested in a shortest path between a fixed pair of points, in a shortest path tree from a single source to many targets, or in all pairs shortest paths. Often one is interested in building a data structure (distance oracle) that can answer efficiently shortest path queries. This area contains many different problems; some of them have been studied extensively. It is motivated by many applications, such as industrial automation and motion planning (in robotics), geographic information systems (GIS).

In this project we are interested in studying the problem of computing a shortest path between points s and t in a polygon P such that the path's intersection with exterior of P is at most one path segment. This is the most related problem to the problem of shortest k violation path in a polygon. Polynomial time algorithm that computes the shortest one violation path is known. We intend to investigate the computational aspect of the generalized version of this problem.

Eligibility for Project-Linked Person:

M. Sc. in CS/MCA or M E / M Tech in CSE/ECE/ETCE or related discipline.

2. Minimum Discriminating Codes in Geometric Setup

Abstract:

Geometric variations of the discriminating code problem are studied in this project. A set of points P and a set of objects S are given in $\mathbb{R}^d$. The objective is to choose a subset $S^* \subseteq S$ of minimum cardinality such that the subsets $S_i^* \subseteq S^*$ covering p_i, satisfy $S_i^* \neq \emptyset$ for each $i=1, 2, ..., n$, and $S_i^*\neq S_j^*$ for each pair (i,j), $i \neq j$. For the 1D version, the objects in S are intervals on a line. If the intervals in S are of arbitrary length, then the problem is NP-complete. A polynomial time 2-approximation algorithm for this problem is proposed. In 2D, for unit square objects S, the problem is NP-hard. Polynomial time approximation algorithms are proposed where the centers of the (unit square) objects can be at arbitrary positions in $\mathbb{R}^2$. Further studies involve considering other types of objects, and proposing improved approximation algorithms.

Eligibility for Project-Linked Person:

M. Sc. in CS/MCA or M E / M Tech in CSE/ECE/ETCE or related discipline.

3. Center Location Problems on Graphs and Plane

Abstract:

Center location problems concern with optimally placing a set of centers within a region such that every part of the region is "close" to some center. Depending on the context, this naturally encompasses many real-life applications in city planning, floor planning, building evacuation sites.

We study the center location problems on graphs and the Euclidean plane. In graphs, a generic center location problem has the following structure. Given a set of demand points represented by vertices, we construct a graph whose edges represent distance between individual vertices. We have to place a set of centers, either on the vertices or edges of the graph such that each demand point is served by at least one center and some specified cost criterion is optimized. In the Euclidean plane both centers and demand

points are actual points on the Euclidean plane and the distance between a center and a demand point is the Euclidean distance between them. Center location problems in graphs and in the Euclidean plane lead to some very interesting algorithmic questions. We address some of these questions in this project and try to settle them.

Eligibility for Project-Linked Person:
EITHER PhD (submitted/awarded) OR
ME/M.Tech./M.Sc. in CS/CSE/Mathematics or related discipline with at least 2 years' research experience in graph/geometry related subjects.

4. Model-Centric Algorithms for Graph-Theoretic, Clustering and Geometric Problems

Abstract:

In the traditional RAM model, we essentially assume that the input data can be completely stored in memory. However, in the age of big-data, this assumption is no longer true and this has led to the development of sub-linear time and space algorithms which access only part of the input and provide approximate solutions with high probability. Two well studied models of computation for the design of sub-linear algorithms are streaming model of computation and query model. In the usual one-pass streaming model of computation, input data appears in a stream or sequence and the objective of the algorithm is to compute an approximate solution using typically polylogarithmic storage space. In the query model, an oracle access to the input is assumed and the objective is to design algorithms and prove lower bounds on the number of queries to compute approximate solutions for computational problems. In this project, we have started to look at sub-linear time/space algorithms for fundamental graph, clustering and geometric problems. For the graph theoretic problems, we are looking at subset queries, that are generalizations of the BIS (bipartite independent set) and IS (independent set) queries.

Eligibility for Project-Linked Person:
M E / M Tech in CSE/ECE/ETCE or related discipline with good academic record; final year final semester students can also apply

5. Computational Topology and its Applications in Topological Data Analysis

Abstract:

We intend to study optimization problems on graphs embedded in low genus surface. We will also work on building the theory of graphs with bounded VC dimensions.

Eligibility for Project-Linked Person: PhD in Computer Science

6. Distributed Algorithms for Fat Robots

Abstract:

A swarm of robots is a body of independent entities who co-operate under distributed control to perform some global task. Most of the existing literature represent the robots as dimensionless points. They do not create obstacle for movements of each other. This project looks at robots as circles on the plane. The immediate problem is that the robots cannot assume that they can find straight line path to their destinations. This creates problems in maintaining invariance in some cases. The aim of the project is to propose efficient algorithms as well as characterize impossible initial configurations for problems such as Gathering, Circle Formation, General Pattern Formation.

Eligibility for Project-Linked Person:
PhD in Computer Science (awarded/submitted). Research experience in the area of Distributed Computing or related area

7. Relay Selection in 5G Device to Device Communication under Uncontrolled Interference

Abstract:

Device to device (D2D) communication in 5G cellular networks is the new paradigm shift which promises ubiquitous and always best connected services given the unprecedented surge in number of mobile users and their bandwidth hungry applications. In D2D communication, devices can either directly send data or can act as relay to further transfer the data to the destination without any assistance from the base station. Relay selection in D2D communication is particularly challenging as the links between the devices show an intermittent characteristics due to device's mobility. Millimeter wave communication may be adopted to provide high data rate but it suffers from severe propagation and penetration losses. So line of sight communication is required while selecting the relay nodes. Finding such path becomes more challenging when both static and dynamic obstacles are present. Also frequency channels must be assigned to the selected links along the path so as to avoid frequent channel switching which may arise due to unpredictable interference from mobile devices. In this project we aim to develop algorithms to find source-destination path consisting of line of sight links in the presence of both static and dynamic obstacles under the uncontrolled interference environment by taking care of device's mobility explicitly.

Eligibility for Project-Linked Person:

M E / M Tech in CSE/ECE/ETCE or related discipline with good academic record; final year final semester students can also apply

8. Machine Learning Based Physical Design Automation for Next Generation ICs

Abstract:

Electronic Design Automation (EDA) for the complex chips has been posed ever-increasing challenges due to feature sizes in the sub-20 nm range on one hand, and fast turn-around times on the other. While next generation lithography beyond 193 nm optical lithography has been the promising avenue for mitigating the problem of printing patterns without distortions, 3D monolithic ICs is the other direction towards meeting the specifications for thermal, power, timing. Both of these avenues are not yet in full-fledged production since certain issues are yet to be resolved.

Traditional multi-objective optimisation formulations for the EDA and in particular physical design have been known to be computationally hard to solve. Meanwhile, there has been significant progress of machine learning technologies which has opened up avenues for improvement of EDA and IC design. The goal of this project is to design and develop efficient machine-learning based algorithms for physical design of modern ICs in sub-20 nm fabrication technology using next generation lithography for 3D monolithic ICs. In particular, developing machine learning based algorithms for lithography hot-spot aware routing in 2D and 3D chips will be addressed.

Eligibility for Project-Linked Person:

M E / M Tech in CSE/ECE/ETCE or related discipline with good academic record; final year final semester students can also apply