S.M. Project Abstracts (2003/2004)

HPCES programme

Auto-Micro Yard Planning

Students	:	Cai Huaning
Thesis Advisor (Singapore)	:	Prof Sun Jie
Company Supervisors	:	Dr Tan Kok Choon & Mr Loh Swee Nam (PSA Corporation Limited)

Project Abstract : Confidential

Development of a Multiobjective Optimization Algorithm to Maintain Diversity in Both Parametric and Objective Spaces

Student	:	Chan Kian Ping
SMA Supervisor	:	Assoc Prof Tai Kang
Company Supervisors	:	Dr Her Mann Tsai & Dr Tapabrata Ray (Temasek Laboratories)

Project Abstract :
A lot of research effort in recent years has been focused on the design of efficient multi-objective optimization (MO) algorithms. Most of the commonly used MO algorithms like Non Dominated Sorting Genetic Algorithm (NSGA), Pareto Archived Evolutionary Strategy (PAES) and the Strength of Pareto Approach (SPEA) have come up with their improved versions in recent years (NGSA-II, SPEA-II etc.). Although, methods like elitism, improved methods for archival, individual replacement, parent selection etc. have improved the performance of these algorithms, none of them are effective in maintaining diversity of the solutions in the variable space (parametric space). In this study, three state-of-the-art MOEAs, namely PAES, SPEA-II and NSGA-II, are examined for their performance in maintaining parametric diversity on a specially designed test function. Two new algorithms based on the new concept of Lebesgue contribution and Neighbour Count to effectively solve multi-objective problems and ensure diversity are introduced and tested on three sets of test problems. The simulation results have shown that the proposed algorithm is capable in finding diverse solutions in parametric space and also capable in locating Pareto-optimal solutions in objective space effectively.

Optimization of Food Manufacturing Facility

Students	:	Choong Chee Huei, Tan Chin Teong, Vasanth Ramesan & Wong Kay Li, Elaine
SMA Supervisor	:	Assoc Prof Teo Chung Piaw
Company Supervisor	:	Mr Michael Chua (Singapore Food Industries Limited)

Project Abstract :
A scheduling tool was developed for Singapore Food Industries Limited (SFI). The production system of SFI is a typical flow shop which is an NP-hard problem. The problem is simplified by using bottleneck scheduling. A prototype implemented as a mathematical model was first tested ILOG OPL. A heuristic solver was developed to provide a cost efficient scheduler to SFI. The heuristic has been designed to give priority to urgent jobs. In addition, the algorithm minimizes job segregation into multiple days and for large jobs, an intelligent job segmentation routine is implemented to avoid unrealistically small job schedules. The final software application is developed in Visual Basic Access running in Microsoft Access. A simulation model was developed to verify the validity of schedules generated by the simplified mathematical model. The bottleneck scheduling approach is feasible. The scheduler was delivered to SFI.

Scheduling Independent Tasks with Migration

Student	:	Deepak Sarda
SMA Supervisor	:	Assoc Prof Wang Jian-Sheng
Company Supervisor	:	Dr Andrew Goryachev (Bioinformatics Institute)

Project Abstract :
A multicellular simulation software is being designed at the Bioinformatics Institute. It works by simulating each individual cell as a process instance and running several such processes on a parallel cluster of computers. To ensure best possible simulation runtimes, the software needs to effectively schedule these processes on the cluster. The present work implements a scheduler module which makes process scheduling decisions for this software. Different scheduling strategies are considered and their relative performance is compared.

Marine Expert System - Pilot Deployment Engine

Student	:	Doan Xuan Vinh
SMA Supervisor	:	Prof Sun Jie
Company Supervisors	:	Dr Tan Kok Choon & Mr Loh Swee Nam (PSA Corporation Limited)

Project Abstract : Confidential

Computational Modeling of Mechano-Chemical Interaction of Cells in Biological Tissue

Student	:	Ho Van Tai
SMA Supervisor	:	Assoc Prof Khoo Boo Cheong
Company Supervisor	:	Dr Andrew Goryachev (Bioinformatics Institute)

Project Abstract :
Creating a mesh is the first step in a wide range of applications, including scientific computing and computer graphics. If we want to achieve good computational results, we have to build a good mesh generation. An algorithm called “Unstructured Mesh Generation using Distance Functions”, and its free source code on Internet written by Matlab language can produce very high quality triangular mesh. In this project, this code will be modified to improve the slow

execution by changing the code into C++ language, to improve the possibility of non-termination, to detect the cases when the mesh does not respect the boundary, and to be able to produce adaptive mesh. This new code will be able to produce very high quality mesh for both convex and non-convex two dimensional shapes. The min quality is always greater than 0.5, the average quality is always greater than 0.95. This is a very high quality mesh compared with Delaunay algorithm.

Development of Adaptive Meshfree Methods for Non-Linear PDEs with Application to Chaotic Vibration

Student	:	Huynh Dinh Bao Phuong
SMA Supervisor	:	Assoc Prof Liu Guirong
Company Supervisor	:	Dr Gu Yuantong (Centre for Advanced Computations in Engineering Science)

Project Abstract :
In this thesis, a new adaptive algorithm using Meshfree strong-form methods for nonlinear Partial Differential Equations has been proposed. The Meshfree methods were used in the scheme are Polynomial Point Interpolation Method and Radial Point Interpolation Method. The adaptivity of the scheme relies on rules for the refinement and coarsening of highly scattered nodes. Two posteriori error estimates based on interpolation error and solution interpolation are presented for static and time-dependent Partial Differential Equations. The nodal refinement scheme in each adaptive step is based on Delaunay triangulation and Voronoi diagram. Good results from numerical examples confirm the good performance of the proposed method.

Method of Moments Analysis of Toroidal Antennas

Student	:	Jin Yanyu
SMA Supervisor	:	Assoc Prof Li Le-Wei
Company Supervisor	:	Dr Zhang Min (Centre for Microwave and Radio Frequency)

Project Abstract :
In this project, a method of moments analysis of single-wound toroidal helix antennas of arbitrary radius is carried out so as to obtain the non-uniform current distributions, and their resulted radiation patterns in both near and far zones. In the Galerkin's method of moments analysis, the Fourier series is considered as the basis function series. As a result, the current distributions along the toroidal helix wires are expressed analytically in terms of the azimuth angle for various diameters of toroidal antennas. Finally, the far-zone radiated fields of contra-wound toroidal helix antennas are expressed analytically using vector potential techniques and their radiation patterns in both near and far zones are determined pictorially.

High Voltage MOSFET Model in ADMS

Student	:	Kerwin Ong Lopez Khu
SMA Supervisor	:	Assoc Prof Li Le-Wei
Company Supervisor	:	Dr Lin Fujiang (Institute of Microelectronics)

Project Abstract :
High voltage MOSFETS are used in driving liquid crystal displays (LCD's). With increasing popularity of LCD's in personal computers and in consumer electronics, there is a corresponding need for a better HVMOS model for use in computer-aided circuit design.

Currently, industry standard models such as BSIM3 provide a poor fit when modeling HVMOS devices. In addition, the parameter extraction procedure required for BSIM3 is very complex.

In this paper, we will develop a custom CAD model using an analytical approach. That is, we will build a model empirically from measured characteristics, with the objective of keeping the equations simple while minimizing the number of parameters.

The main problem of custom models, however, is that they are difficult to integrate into commercial simulators. Our approach addresses this problem by implementing our model using the up-and-coming Automatic Device Model Synthesizer (ADMS) tool [3]. ADMS is based on the open high-level language Verilog-A, from which it generates C code for specific simulators.

Distributed Mesh Generation for Computational Modeling of Cardiovascular Flow over a Grid Computing Environment

Student	:	Le Huynh Nguyen Khang
SMA Supervisor	:	Assoc Prof Murali Damodaran
Company Supervisor	:	Dr Arun Krishnan (Bioinformatics Institute)

Project Abstract :
This study examined the possibility of executing a commercial software over a grid computing environment. The mesh generation software, GAMBIT, was used to create computational meshes of the left ventricle of a human heart at seventeen instances between the systole and diastole periods. This process was done over the grid, using two machines at The Supercomputing and Visualization Unit (SVU) in National University of Singapore (NUS). The author focused on analyzing the overall running time when varying the number of jobs executed on both machines in order to estimate the performance of the application on the grid. The results showed that the running time decreased significantly when the jobs were run over the grid. Also, the study proved the potential of exploiting advantageous features of the grid to run commercial softwares among grid nodes in order to save money and time.

Pricing and Returns Strategies for Short-Life Cycle Products

Student	:	Lim Yong Beng
SMA Supervisor	:	Asst Prof Chou Cheng-Feng Mabel
Company Supervisor	:	Dr Yuan Xue Ming (Singapore Institute of Manufacturing Technology)

Project Abstract :
To encourage the retailers to buy more, the manufacturer may offer various pricing and returns strategies to provide some form of insurance to them. Such strategies or policies are especially important for products with highly uncertain demands and short life cycle products whose functionality or market will die away after a short period of time. Thus, without any assurance from the manufacturer, the retailers will tend to reduce the order quantity to avoid high over-stocking cost.

The easiest returns policy to implement would be to offer payback of whatever goods that are unsold by the retailers. Though the manufacturer may achieve the initial sales target with such a policy, the ensuing payback of returned goods could cancel off the initial profit and even create a loss. To curb the retailers' tendency to overstock, this research project will look into 2 types of partial returns policies. Namely, they are Full Returns Partial Credit and Partial Returns Full Credit returns policies. The former policy allows the return of all goods bought by retailers at a lower credit price than the initial wholesale price. The latter policy only allows partial returns of the quantity bought by the retailers, but with the credit of full wholesale price.

This project will investigate how the optimal returns policy may be obtained based solely on maximizing the manufacturer's profit. Initial approach based on pure mathematical analysis cannot be resolved due to the use of generic demand distribution. To address this issue, a normal distribution is used but there are difficulties in solving the integral of the normal function. Hence, the exponential distribution is used. With this demand model, the optimal retail price and quantity may be determined for a specific pricing and returns policy. Subsequently, the related manufacturer profit can be found. Thus, by iterating over the possible policies, the optimal policy that maximizes the manufacturer profit can be obtained.

Based on a same set of parameters, the former policy seems to perform better than the latter policy with higher profit for both retailers and manufacturer. This statement is verified further with more sets of varying parameters. In all, offering partial returns policy (especially the former type) will benefit the manufacturer substantially than without returns policy.

Examine the Returns Policies - From a Manufacturer's Perspective

Student	:	Lin Cheng
SMA Supervisor	:	Asst Prof Chou Cheng-Feng Mabel
Company Supervisor	:	Dr Cao Chengxuan (The Logistics Institute – Asia Pacific)

Project Abstract :
Different returns policy, which specifies different schedule of rebates from manufacturer to retailer for unsold products at the end of the selling season will influence the retailer's decision on order quantity and can bring manufacturer different profit. We take the viewpoint of a manufacturer selling short life-cycle products to a single retailer and compare two kinds of returns policies. The first is called "pooled" returns policy in which the distributor can return any combination of the products up to R percent of the total purchases across all products. To our knowledge, this policy has not been examined in the literature even though it has been commonly used in distribution of high-tech products. The second is "non-pooled" returns policy under which the distributor can return each product separately up to R percent of the purchase of that product. By considering the 2-product case for different cases, we found the optimal quantity may be less under pooled returns policy and manufacturer may achieve higher profit under pooled returns policy under specific cases; while numerical results show that when the manufacturer could adjust return rate freely, he could achieve higher profit under non-pooled returns policy.

RNA Structure Analysis using Genetic Algorithms

Student	:	Liw Meng Hong
SMA Supervisor	:	Assoc Prof Tai Kang
Company Supervisor	:	Dr Li Kuo-Bin (Bioinformatics Institute)

Project Abstract : Not available at this time

Mathematical Analysis of a Bacterial Growth Population Model

Student	:	Pang Chin How, Jeffrey
SMA Supervisor	:	Assoc Prof Liu Guirong
Company Supervisor	:	Dr Andrew Goryachev (Bioinformatics Institute)

Project Abstract :
We investigate a large Bio Chemical model that consists of around 30 reactions and 10 species in this report. With a few quasi static assumptions, we simplify the reaction model to observe the dependence of the bifurcation diagram with respect to the rate constants. Exact conditions for determining the stage in the bifurcation diagram given specific parameters are found, and approximate conditions are suggested.

Our analysis is much simplified when we arrive at a rational function. This allows us to use standard results in polynomials to perform our analysis. We also explore the best approximation in a given space using polynomials so that we will have better approximations.

Creation of a Gene Expression Database

Student	:	Prerit Mittal
SMA Supervisor	:	Assoc Prof Murali Damodaran
Company Supervisor	:	Dr Yang He (Bioinformatics Institute)

Project Abstract :
A critical part of microarray experimentation and subsequent data analysis is the ability to collaboratively and meaningfully share the enormous amount of data and information that describe individual experiments. Lack of standards for presenting and exchanging data makes relative comparison of microarray experiments produced in separate research environments a near impossibility. The power of microarray analysis can be realized only if data is systematically archived and linked to biological annotations. This project aims at countering some of the issues faced in microarray data comparison. The issues include keeping track of changing gene annotation. The database uses open source versions of MySql and has been implemented using Java and related technologies.

Software Development and Modeling for Practical Manpower Scheduling Problems

Student	:	Seetoh Kin Choong
SMA Supervisor	:	Prof Huang Huei Chuen
Company Supervisor	:	Mr Tang Shouwei (Knowledge Touch Pte Ltd)

Project Abstract :
In the real world, scheduling a workforce is often a tedious difficult task when done manually. Often, businesses suffer losses from inefficient usage of available resources because of poorly developed or even erroneous schedules. PeopleScheduler, a software suite developed by Knowledge Touch seeks to alleviate this problem by generating not only feasible schedules, but optimal ones as well by formulating the scheduling problems and solving them via optimisation methods.

Part of the customisation and development of the PeopleScheduler was proposed and performed in view of a customer's needs for the first part of this project. These include the design and development of suitable interfaces, database storage tables as well as necessary functions that were integrated into the existing software.

A Mixed-Integer Programming (MIP) model was proposed and tested for a new scheduling problem for another customer in the second part of this project, after which, it would be implemented in PeopleScheduler.

Modeling and Optimization of UWB Antennas by Mode Expansion Method

Student	:	Shen Dawei
SMA Supervisor	:	Assoc Prof Li Le-Wei
Company Supervisor	:	Dr Chen Zhining (Institute for Infocomm Research)

Project Abstract :
For an antenna with a particular coaxially fed monopole structure, the inherently narrow impedance bandwidth is a primary weakness known. The bandwidth performance is actually a function of the antenna dimensions. Naturally, we wish to search all possible dimensions to acquire the antenna with the best bandwidth performance. However, due to structure complexity, it is hard to model this kind of system using most existing numerical schemes. Traditional numerical modeling scheme takes too long time to evaluate the performance for one single set of dimension parameters, which makes the optimization procedure unbearably slow.

Fortunately, for cylindrical structure, mode expansion techniques are straight-forward but powerful mathematical tools to model the structure. The high time efficiency of mode expansion method makes it possible to integrate optimization techniques such as Genetic Algorithm. In this dissertation, a new type of monopole with a top-hat and an annulus will be modeled and numerical analyzed using mode expansion techniques. Then Genetic Algorithm would be used to best broaden the bandwidth and try to find an antenna that satisfies the bandwidth requirement for both Bluetooth system and WLAN.

An MDO Framework for Conceptual Aircraft Configuration Design

Student	:	Tan Lian Hing
SMA Supervisor	:	Assoc Prof Tai Kang
Company Supervisors	:	Dr Her Mann Tsai & Dr Tapabrata Ray (Temasek Laboratories)

Project Abstract :
At the conceptual phase of any engineering design process, the aim is to determine a set of design features that meet various performance characteristics. A typical engineering system is a complex system with strong inter-subsystem interaction. Multidisciplinary Design Optimization (MDO) at this phase allows the designer to consider various options via simultaneous interactions of various subsystems to arrive at a better design.

The geometry of any system determines the ultimate system performance. This shows the need for a **geometry modeller** which can model the system geometry accurately and efficiently. The initial development of such **geometry modeller** is based on an aircraft consisting of fuselage, wing/tail and pylon. It is possible to model more complex system through the use of **NURBS** (Nonuniform Rational B-Splines).

A **MDO framework** is developed to perform MDO to seek for better system design by using evolutionary algorithm. The **MDO framework** is easy to use and

allows different evolutionary algorithms to be incorporated into the framework.

Selection of Vessels for Multiple Berthing

Student	:	Tri Dung Nguyen
SMA Supervisor	:	Prof Sun Jie
Company Supervisors	:	Dr Tan Kok Choon & Mr Loh Swee Nam (PSA Corporation Limited)

Project Abstract : Confidential

Modeling of Complex Cooperative Behavior in Bacterial Population Growth

Student	:	Vinay Sarathy
SMA Supervisor	:	Assoc Prof Khoo Boo Cheong
Company Supervisor	:	Dr Andrew Goryachev (Bioinformatics Institute)

Project Abstract : Confidential

Simulation and Optimization of Cylindrical Antenna using Mode Match Method

Student	:	Wang Ning
SMA Supervisor	:	Assoc Prof Li Le-Wei
Company Supervisor	:	Dr Chen Zhining (Institute for Infocomm Research)

Project Abstract :
The purpose of this research project is to integrate the powerful optimization method into practical antenna design techniques. Since the development of electrical systems, higher frequency, broader bandwidth and smaller volume antennas are required by many applications. However, because of the complexity of simulating general structure antennas, the parameter optimization process becomes very hard. The motivation of this work is to reduce the complexity of optimizing cylindrical antennas.

In this work, a particular type of antennas has been studied, and a very powerful method (Modal Matching Method) is adopted to model the structure. Since the effectiveness of the Modal Matching Method applying to this particular type of antennas, the optimization procedure becomes realizable.

Setting the objective to broaden the bandwidth in the frequency range from 4-8GHz, the Geometric parameters of the antenna are optimized using the Genetic Algorithm. Some important issues have been discussed for both modeling method and optimization procedure, and regarding the optimized antenna, a section of parameter study have been presented.

Fast Computation of Sommerfeld Type Integrals and Applications

Student	:	Wang Yue
SMA Supervisor	:	Assoc Prof Li Le-Wei
Company Supervisor	:	Dr Li Jianying (Centre for Microwave and Radio Frequency)

Project Abstract :
The dyadic Green's function (DGF) has been involved frequently in the investigation of the interaction of electromagnetic waves with the layered media in the boundary value problems. When the DGF is known then the electromagnetic fields can be formulated easily in terms of an integral containing the Green's function and an arbitrary current distribution of the excitation source.

The dyadic Green's functions for planarly multilayered media, like those for other media, e.g., spherically stratified and cylindrically layered media, have received increasingly interests over the past years. More recently, the study in dyadic Green's function in both the planar and sphere geometry has been extended to media of more complicated geometries. Although a generally expression of dyadic Green's function for both the multilayered sphere case has been given by *Li* in [2]. We have known that the Green's function for the planar case is in the form of the integral plus a summation. We generally refer to this kind of expression as *Sommerfeld Integral*. In order to evaluate the electromagnetic field of these kind, we need to evaluate the value for the so called *Sommerfeld Integral*, which, till now is very difficult involving the method of DCIM.

We don't have the analytical form for planar geometry although the analytical form would be a valuable approach for deeper investigation for the stratified planar electromagnetic field. But according to *Li* we have the analytical form of the dyadic Green's function for the spherical multilayered case, we may have a chance to derive the analytical solution of the Green's function for the planar multilayered geometry from the spherical multilayered geometry. In this paper we will study the formulation of the multilayered planar dyadic Green's function based on spherical dyadic Green's function. Also, simulation results of dipole radiation over multilayered sphere earth are also provided.

Multiobjective Optimization under Uncertainty and its use for Robust Design

Student	:	Yang Liu
SMA Supervisor	:	Assoc Prof Tai Kang
Company Supervisors	:	Dr Her Mann Tsai & Dr Tapabrata Ray (Temasek Laboratories)

Project Abstract :
Computation cost becomes a big problem in robust optimization process because it requires numerous actual function evaluations which are always very expensive. In this paper, a new computational efficient model based on evolutionary optimization method is proposed to solve robust design optimization problems. A multi-objective formulation is considered that takes an individual's performance and the standard deviation of its neighborhood performance as two objectives subject to the feasibility of itself and its neighborhood. The computational effort is successfully reduced by using Taylor Series expansion base on RBF (Radial Basis Function)

approximation in neighborhood evaluation instead of the actual analyses. Furthermore, a parallel scheme is proposed to make it more effective. The effectiveness of the suggested method is examined by solving six well-studied engineering design examples and the results are compared with other three methods (explained in section 2.2). Moreover, the deterministic optimal results reported in literature are evaluated by our algorithm to show the difference between an optimal solution and a robust optimal solution.

Statistical Inference of Gene Networks from Microarray Data

Student	:	Yin Thing-Yew
SMA Supervisor	:	Assoc Prof Wang Jian-Sheng
Company Supervisor	:	Dr Andrew Goryachev (Bioinformatics Institute)

Project Abstract :
Pre-existing unfolded gene expression data obtained from cDNA microarrays for the liver disease Biliary Atresia is analyzed with a parametric statistical test. The statistic is the correlation coefficient of gene expression level for any given pair of genes, tested for significant difference between data from liver samples affected by Biliary Atresia and data from disease-free liver tissue. A C++ implementation achieved good performance on a Linux based laptop computer. Computationally intensive bootstrapping and network identification algorithms are employed to analyze the impact of noise and to find commonalities with results from previous studies on Biliary Atresia.

Variable-Length OPC Methodology

Student	:	Yuan Dongning
SMA Supervisor	:	Assoc Prof Wang Jian-Sheng
Company Supervisor	:	Mr Andrew Khoh (Chartered Semiconductor Manufacturing Ltd)

Project Abstract : Confidential