The 3rd

Workshop on Industrial Applications

City University of Hong Kong

Hong Kong

December 7-11, 2009

Workshop Guide

Web site: http://www6.cityu.edu.hk/rcms/WIA2009/

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Introduction

This is the third Workshop on Industrial Application held at City University of Hong Kong from December 7-11, 2009.

The Workshop which firstly started in Oxford in 1968, has created a mutually beneficial link between academic researchers and their counterparts in public and private sectors. Over the past four decades, the Oxford Study Group model has been adopted in many countries in Europe, North America, Australia, New Zealand and Asia.

We organized the same series of Workshop in 2002 and in 2006 at CityU. Most participants of the Workshop, including American International Assurance (Bermuda) Ltd., China Light & Power Hong Kong Ltd., Hong Kong Observatory, Pacific Century CyberWorks, State Street Bank and Baoshan Iron & Steel Co. Ltd., Reuters Hong Kong Ltd., SAE Magnetics (HK) Ltd., Nippon Steel Co., Japan, and Inspecting Station of Geology and Environment in Zibo appreciated this unique opportunity to share their research experience with experts from UK, Canada and Australia.

The third workshop is in collaboration with Fields Institute for Research in Mathematical Sciences in Canana. As one of the LBJ Centre's collaboration partners since Oct 2007, the Fields Institute has co-organized with LBJ centre the Fields-MITACS Industrial Problem-Solving Workshop in August 2008 in Toronto.

This event will provide a unique opportunity for applied mathematicians to be exposed to industrial problems. It will also help to establish link between industry and university, and in particular to encourage the greater use of mathematical modeling and analysis in industry.

Organizing Committee

Advisors

Ta-tsien Li, Fudan University, China
John Ockendon, Oxford University, UK
Shige Peng, Shandong University, China
Roderick Wong, City University of Hong Kong, Hong Kong

Organizers

K. W. Chung, City University of Hong Kong, Hong Kong
H.-H. Dai, City University of Hong Kong, Hong Kong
Daniel Ho, City University of Hong Kong, Hong Kong
Huaxiong Huang, York University, Canada
Yongji Tan, Fudan University, China
Jonathan Wylie, City University of Hong Kong, Hong Kong

Industry Representatives

Finance:	Mapleridge Capital Corporation
Hi-tech:	Shanghai Huayuan Analytic Technology Co. Interactive Systems & Technologies Limited
Engineering:	Chengdu University of Technology Ove Arup & Partners Hong Kong Limited
Environmental:	Institute of Environmental Science and Technology, Shandong University of Technology

Workshop Programme

Updated schedule information may be posted outside lecture theatre LT-1, Academic Building.

December 7, 2009 (Monday)

9:30am – 10:15am	**Registration**	LT-1
10:15am – 10:30am	**Opening Ceremony**	LT-1
Morning session: 10:30am – 12:00pm Chair: Yongji Tan		
10:30am – 11:00am	Presentation by Chengdu University of Technology	LT-1
11:00am – 11:30am	Presentation by Institute of Environmental Science and Technology, Shandong University of Technology	LT-1
11:30am – 12:00noon	Presentation by Shanghai Huayuan Anlytic Technology Co.	LT-1
12:00noon – 1:30pm	Lunch Break	
Afternoon session: 1:30pm – 3:00pm Chair: K. W. Chung		
1:30pm – 2:00pm	Presentation by Ove Arup & Partners Hong Kong Limited	LT-1
2:00pm – 2:30pm	Presentation by Mapleridge Capital Corporation	LT-1
2:30pm – 3:00pm	Presentation by Interactive Systems & Technologies Limited	LT-1
3:00pm – 3:30pm	Coffee Break	

3:30pm-5:00pm	**Discussions in class rooms**	
	Inversion of Electrical Conductivity Parameters in Double-Layered Earth with 3-Dimensional Anomalies	Y5-202
	Evaluation of Environmental Quality and Evolution in Urban Soils of Qingdao City	Y5-203
	Service Center Optimization (Nonlinear Integer Programming)	Y5-204
	Computational Fluid Dynamics (CFD) Modelling on Soot Yield for Fire Engineering Assessment	Y5-205
	Modelling PWM control of a single phase induction motor	Y5-103
	Regime Changes in Non-Stationary Time-Series	Y5-104
5:15pm – 7:30pm	**Welcome Reception** at 9/F, City Top, Amenities Building, City University of Hong Kong	

December 8, 2009 (Tuesday)

9:30am – 12:00noon	**Work on Problems**	
	Inversion of Electrical Conductivity Parameters in Double-Layered Earth with 3-Dimensional Anomalies	Y5-202
	Evaluation of Environmental Quality and Evolution in Urban Soils of Qingdao City	Y5-203
10:30am – 11:00am *Coffee Break* *outside Y5-205*	Service Center Optimization (Nonlinear Integer Programming)	Y5-204
	Computational Fluid Dynamics (CFD) Modelling on Soot Yield for Fire Engineering Assessment	Y5-205
	Modelling PWM control of a single phase induction motor	Y5-103
	Regime Changes in Non-Stationary Time-Series	Y5-104
12:00noon – 1:30pm	Lunch Break	
1:30pm – 5:30pm	**Work on Problems**	
	Inversion of Electrical Conductivity Parameters in Double-Layered Earth with 3-Dimensional Anomalies	Y5-202
	Evaluation of Environmental Quality and Evolution in Urban Soils of Qingdao City	Y5-203
3:00pm – 3:30pm *Coffee Break* *outside Y5-205*	Service Center Optimization (Nonlinear Integer Programming)	Y5-204
	Computational Fluid Dynamics (CFD) Modelling on Soot Yield for Fire Engineering Assessment	Y5-205
	Modelling PWM control of a single phase induction motor	Y5-103
	Regime Changes in Non-Stationary Time-Series	Y5-104

December 9, 2009 (Wednesday)

9:30am – 12:00noon	**Work on Problems**	
	Inversion of Electrical Conductivity Parameters in Double-Layered Earth with 3-Dimensional Anomalies	Y5-202
	Evaluation of Environmental Quality and Evolution in Urban Soils of Qingdao City	Y5-203
10:30am – 11:00am *Coffee Break* *outside Y5-205*	Service Center Optimization (Nonlinear Integer Programming)	Y5-204
	Computational Fluid Dynamics (CFD) Modelling on Soot Yield for Fire Engineering Assessment	Y5-205
	Modelling PWM control of a single phase induction motor	Y5-103
	Regime Changes in Non-Stationary Time-Series	Y5-104
12:00noon – 1:30pm	Lunch Break	
1:30pm – 3:00pm	**Work on Problems**	
	Inversion of Electrical Conductivity Parameters in Double-Layered Earth with 3-Dimensional Anomalies	Y5-202
	Evaluation of Environmental Quality and Evolution in Urban Soils of Qingdao City	Y5-203
	Service Center Optimization (Nonlinear Integer Programming)	Y5-204
	Computational Fluid Dynamics (CFD) Modelling on Soot Yield for Fire Engineering Assessment	Y5-205
	Modelling PWM control of a single phase induction motor	Y5-103
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3:00pm – 3:30pm	Coffee Break	outside Y5-205

3:30pm-5:00pm	**Brief presentation of solution of problems** *Char: Daniel W. C. Ho*	LT-1
3:30pm-3:45pm	Inversion of Electrical Conductivity Parameters in Double-Layered Earth with 3-Dimensional Anomalies	
3:45pm-4:00pm	Evaluation of Environmental Quality and Evolution in Urban Soils of Qingdao City	
4:00pm-4:15pm	Service Center Optimization (Nonlinear Integer Programming)	
4:00pm-4:30pm	Computational Fluid Dynamics (CFD) Modelling on Soot Yield for Fire Engineering Assessment	
4:30pm-4:45pm	Modelling PWM control of a single phase induction motor	
4:45pm-5:00pm	Regime Changes in Non-Stationary Time-Series	
6:30pm – 8:30pm	Banquet[#] at City Chinese restaurant 8/F, Amenities Building City University of Hong Kong	

December 10, 2009 (Thursday)

9:30am – 12:00noon	**Work on Problems**	
	Inversion of Electrical Conductivity Parameters in Double-Layered Earth with 3-Dimensional Anomalies	Y5-202
	Evaluation of Environmental Quality and Evolution in Urban Soils of Qingdao City	Y5-203
10:30am – 11:00am *Coffee Break* *outside Y5-205*	Service Center Optimization (Nonlinear Integer Programming)	Y5-204
	Computational Fluid Dynamics (CFD) Modelling on Soot Yield for Fire Engineering Assessment	Y5-205
	Modelling PWM control of a single phase induction motor	Y5-103
	Regime Changes in Non-Stationary Time-Series	Y5-104
12:00noon – 1:30pm	Lunch Break	
1:30pm – 5:30pm	**Work on Problems**	
	Inversion of Electrical Conductivity Parameters in Double-Layered Earth with 3-Dimensional Anomalies	Y5-202
	Evaluation of Environmental Quality and Evolution in Urban Soils of Qingdao City	Y5-203
3:00pm – 3:30pm *Coffee Break* *outside Y5-205*	Service Center Optimization (Nonlinear Integer Programming)	Y5-204
	Computational Fluid Dynamics (CFD) Modelling on Soot Yield for Fire Engineering Assessment	Y5-205
	Modelling PWM control of a single phase induction motor	Y5-103
	Regime Changes in Non-Stationary Time-Series	Y5-104

December 11, 2009 (Friday)

First session: 9:30am – 10:30pm Chair: Huaxiong Huang		
9:00am – 9:20am	Presentation to Chengdu University of Technology	LT-1
9:20am – 9:40am	Presentation to Institute of Environmental Science and Technology, Shandong University of Technology	LT-1
10:00am – 10:20am	Presentation to Shanghai Huayuan Analytic Technology Co.	LT-1
10:20am – 10:50am	Coffee Break	
Second session: 11:00am – 12:20pm Chair: Hui-Hui Dai		
10:50am – 11:10am	Presentation to Ove Arup & Partners Hong Kong Limited	LT-1
11:10am – 11:30am	Presentation to Mapleridge Capital Corporation	LT-1
11:30am – 11:50am	Presentation to Interactive Systems & Technologies Limited	LT-1
11:50am – 12:00noon	Closing Remarks	LT-1
12:00noon – 1:00pm	Lunch Break	

Industrial Problems

Inversion of Electrical Conductivity Parameters in Double-Layered Earth with 3-Dimensional Anomalies

Organization: *Chengdu University of technology, Chengdu, China*

Presenter: *Wang Wenjuan*

E-mail: *wjwangcd@126.com*

Electromagnetic detection is one of the most important methods of geophysical exploration. It is superior to other methods in remote sensing telemetry and subsurface fluid detection. One of the main purposes of electromagnetic detection is to obtain the distribution of electromagnetic parameters of target objects through electromagnetic imaging. Interpretation and inferences can be made from the distribution of such parameters. The differences of electromagnetic parameters of different objects are the physical basis of electromagnetic imaging, whereas the theoretical basis is the characterization of electromagnetic parameters by medium types.

In electrical prospecting on three-dimensional geoelectric structures, the most important methods employed by numerical simulations include finite difference, finite element and integral equation. The first two methods are to divide the whole space,whereas the latter needs only to divide anomalies, and simulates the responses of anomalies of limited size.

The geoelectricity study we present here targets double-layered earth structures with three-dimensional anomalies. Scattering and superposition methods are used to deduce a two-layer Dyadic Green's function. With BVP transforms of integral equation, we can obtain the required electromagnetic parameters, such as the conductivity values.

The geoelectricity framework is illustrated by Figure 1 below. The earth is divided into two layers: the upper is the air layer, the lower is the soil layer which contains anomalies. Both are considered homogeneous and isotropic. Resistivity can change in the anomalies and the earth is excited by the impressed current. Suppose the permeability of soil μ is μ_0, and we ignore the current displacement.

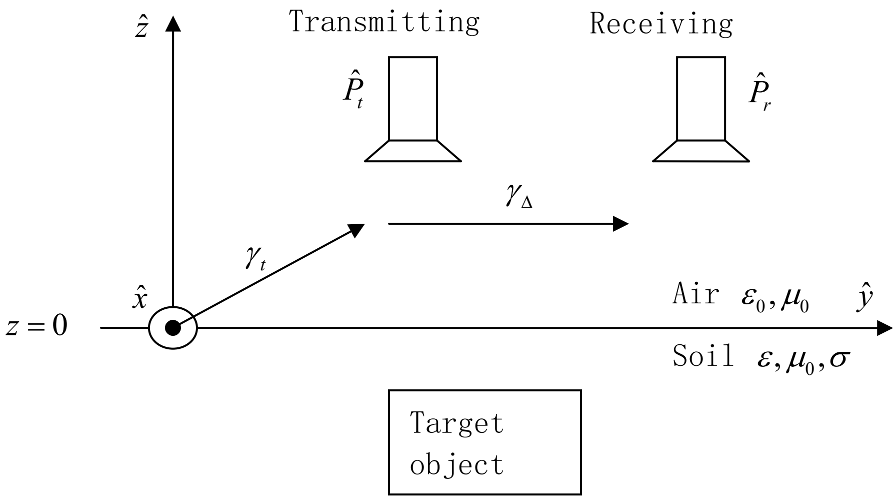

Figure 1

In the frequency domain, Maxwell's equations are as follows:

$$\nabla \times \mathbf{E} = i\omega\mu_0 \mathbf{H} \tag{1}$$

$$\nabla \times \mathbf{H} = \mathbf{J} + (\sigma - i\omega\varepsilon_0)\mathbf{E} \tag{2}$$

Two zones, namely the wave number： $k_1^{\,2} = \omega^2 \mu_0 \varepsilon_0 \approx 0$， $k_2^{\,2} = \omega^2 \mu_0 \varepsilon_2 = i\omega\mu_0\sigma_b$ 。

According to Dyadic Green's function theory, the third category will be used. The solution of electric field strength from (1) and (2) is equivalent to that of the following integral equation:

$$\mathbf{E(R)} = \mathbf{E}_p\mathbf{(R)} + i\omega\mu_0 \int_{V_A} (\sigma - \sigma_b) \overline{\overline{G}}_e(\mathbf{R},\mathbf{R}') \cdot \mathbf{E(R')} dV' \tag{3}$$

This is a second class of singular, vector Fredholm integral equation. Here $\mathbf{E}_p\mathbf{(R)}$ is the primary field of exciting source, and $\overline{\overline{G}}_e(\mathbf{R},\mathbf{R}')$ is the third type of Dyadic Green's function. The electric field in V_A can be derived from the (3). By applying the appropriate Dyadic Green's functions, the electric field at any point of the space can be obtained.

To facilitate numerical calculation, the study area is divided into unit cubes, and the conductivity of the discrete element is set to a constant, that is, each unit cube has a constant electric field (3) can then be rewritten as the following form of discrete units:

$$\mathbf{E(R)} = \mathbf{E}_p\mathbf{(R)} + i\omega\mu_0 \sum_{n=1}^{N} (\sigma_n - \sigma_b) \int_{V_A} \overline{\overline{G}}_e(\mathbf{R},\mathbf{R}') dV' \cdot \mathbf{E}_n \tag{4}$$

The focal point of the electric field for the m-th unit cube can be expressed as

$$\mathbf{E}_m = \mathbf{E}_{pm} + i\omega\mu_0 \sum_{n=1}^{N} (\sigma_n - \sigma_b) \int_{V_A} \overline{\overline{G}}_e(\mathbf{R}_m, \mathbf{R}') dV' \cdot \mathbf{E}_n \tag{5}$$

By rewriting the above as a matrix equation, we get

$$\sum_{n=1}^{N} [i\omega\mu_0 (\sigma_n - \sigma_b) \int_{V_A} \overline{\overline{G}}_e(\mathbf{R}_m, \mathbf{R}') dV' - \boldsymbol{\delta}_{mn}] \cdot \mathbf{E}_n = -\mathbf{E}_{pm} \tag{6}$$

where

$$\boldsymbol{\delta}_{mn} = \begin{cases} \mathbf{I} & when \;\; m = n \\ \mathbf{0} & when \;\; m \neq n \end{cases} \qquad m = 1, 2, 3, \cdots, N \tag{7}$$

And $\mathbf{I}$ is the unit vector. By solving (6), we can obtain the focal point for each discrete element of the electric field. The discrete electric field at any point can then be calculated from (4).

Questions：

1. How do we accurately calculate the volume integral of the Green's function of about cube of the current $\int_{V_A} \overline{\overline{G}}_e(\mathbf{R}_m, \mathbf{R}') dV'$?

2. When we consider the frequency of excitation in different conditions, the first focal point of the electric field of each cell can be expressed as:

$$\mathbf{E}_m^{(1)} = \mathbf{E}_{pm}^{(1)} + i\omega_1\mu_0 (\sigma_A - \sigma_b) \sum_{n=1}^{N} \int_{V_A} \mathbf{G}(\mathbf{R}_m, \mathbf{R}') dV' \cdot \mathbf{E}_n^{(1)} \tag{8}$$

$$\mathbf{E}_m^{(2)} = \mathbf{E}_{pm}^{(2)} + i\omega_2\mu_0 (\sigma_A - \sigma_b) \sum_{n=1}^{N} \int_{V_A} \mathbf{G}(\mathbf{R}_m, \mathbf{R}') dV' \cdot \mathbf{E}_n^{(2)} \tag{9}$$

It remains to be studied as how to calculate the conductivity parameters σ_b ?

Evaluation of Environmental Quality and Evolution in Urban Soils of Qingdao City

Organization: Institute of Environmental Science and Technology
Shandong University of Technology, Zibo, China

Presenter: *Li Gongsheng*

E-mail: *ligs@sdut.edu.cn*

Problem Sketch:

In order to study the environmental geochemical characteristics of urban soils in Qingdao, an extensive soil geological survey was carried out in the Shinan, Shibei, Sifang, Licang and Chengyang districts of Qingdao city.

A total of 319 surface soil samples (at 0~10cm depth) were taken with a density of 1 sample per 1 kilometer square. By utilizing several analytic instruments, the concentrations of 70 elements in the soil samples were determined.

What we know about the problem are:

1. The coordinates of 319 sample sites are known, and some environmental factors about the sample sites are also known;
2. The concentrations of 70 elements in 319 sites are all known, i.e. we have measured data of 70*319=22330.

Question:

1. Is there a quantitative model describing heavy metals (such as Cd, Cr, Cu, Ni, Pb, Zn and As) distribution and their relations? What about for rare earths elements?
2. As compared with the background values, can we find some pollution sources characteristics for heavy metals? Can we construct an evolution model to describe the process and make some prediction?
3. How to evaluate impacts of human activities on the soils environmental quality in mathematics?

Service Center Optimization (Nonlinear Integer Programming)

Organization: *Shanghai Huayuan analytic technology Co., Shanghai, China*
Presenter: *Xuan Xiaohua*
E-mail: *xmxuan@yahoo.com*

Question:

1. Is there any fast algorithm to solve the following problem?

Problem: Let

1. the ideal number of service centers in the region of level 1-5 be X1，X2，X3，X4，X5
2. the current number of service centers of level 1-5 be N1，N2，N3，N4，N5
3. the capability of service center of level 1-5 be a1，a2，a3，a4，a5
4. the unit cost of the capability of service centers of level 1-5 be C1，C2，C3，C4，C5
5. the total capability of service centers in the region should be in [Dmin，Dmax]
6. the total number of service centers of competitor in the region is N’

The ideal structure of service centers in the region should satisfy:

1. Total capability fits the service demand
2. Total of number of service centers match competitors’ level in some sense
3. The level structure match some pre-defined proportion, p1：p2：p3：p4：p5
4. Total service cost if low
5. The change to current structure is small

This can be written as the following optimization problem:

$$\mathrm{D}_{\min} <= \mathrm{a}_1\mathrm{X}_1 + \mathrm{a}_2\mathrm{X}_2 + \mathrm{a}_3\mathrm{X}_3 + \mathrm{a}_4\mathrm{X}_4 + \mathrm{a}_5\mathrm{X}_5 <= \mathrm{D}_{\max}$$

$$\mathrm{P}_{\min}\,\mathrm{N}' <= \mathrm{X}_1 + \mathrm{X}_2 + \mathrm{X}_3 + \mathrm{X}_4 + \mathrm{X}_5 <= \mathrm{P}_{\max}\,\mathrm{N}'$$

$$X_1 : X_2 : X_3 : X_4 : X_5 \approx \mathrm{p}_1 : \mathrm{p}_2 : \mathrm{p}_3 : \mathrm{p}_4 : \mathrm{p}_5$$

$$Min\begin{cases} \mathrm{a}_1\mathrm{C}_1\mathrm{X}_1 + \mathrm{a}_2\mathrm{C}_2\mathrm{X}_2 + \mathrm{a}_3\mathrm{C}_3\mathrm{X}_3 + \mathrm{a}_4\mathrm{C}_4\mathrm{X}_4 + \mathrm{a}_5\mathrm{C}_5\mathrm{X}_5 \\ \sqrt{(\frac{X_1-N_1}{N_1})^2 + (\frac{X_2-N_2}{N_2})^2 + (\frac{X_3-N_3}{N_3})^2 + (\frac{X_4-N_4}{N_4})^2 + (\frac{X_5-N_5}{N_5})^2} \end{cases}$$

Computational Fluid Dynamics (CFD) Modelling on Soot Yield for Fire Engineering Assessment

Organization: *Ove Arup & Partners Hong Kong Limited, Hong Kong*

Presenter: *Dr. Yong S. Y. Wong*

E-mail: *young.wong@arup.com*

Background:

Computational Fluid Dynamic (CFD) Modelling is now widely used by fire safety engineers throughout the world as a tool for predicting smoke movement and tenability analysis. CFD model has often been used to justify the performance of the smoke control design as part of the performance based fire safety design in the current industry.

Typically the smoke extraction rate, number of smoke extraction point and the layout of smoke extraction point are designed using empirical equations from technical guidance such as NFPA 92B [1], NFPA 204 [2], CIBSE Guide E [3], etc. All design parameters of the smoke control strategy and architectural design will be input in the CFD model for analysis. The below are examples of empirical equations extracted from NFPA 92Band NFPA 204.

$$D = \left(\frac{4Q}{\pi Q''}\right)^{1/2} \qquad \text{Eqt(1)}$$

$$z_l = -1.02D + 0.235 Q_c^{2/5} \qquad \text{Eqt(2)}$$

$$z_o = 0.083 Q^{2/5} - 1.02D \qquad \text{Eqt(3)}$$

$$T = T_o + \frac{Q}{1.5 m C_p} \qquad \text{Eqt(4)}$$

$$m = [0.071 Q_c^{1/3} (z - z_o)^{5/3}][1 + 0.027 Q_c^{2/3} (z - z_o)^{-5/3}] \quad \text{(If } z > z_l\text{)} \qquad \text{Eqt(5)}$$

$$m = 0.0056 Q_c \ (z / z_l) \quad \text{(If } z < z_l\text{)} \qquad \text{Eqt(6)}$$

$$V = \frac{m}{\rho_o} + \frac{Q}{1.5 \rho_o T_o C_p} \qquad \text{Eqt(7)}$$

where,

Q = instantaneous heat release rate (kW);

Q_c = convective portion of heat release rate (kW);

Q'' = heat release rate per unit floor area (kW/m²);

zl = mean flame height above the base of the fire (m);

z = height of the smoke layer boundary above the base of fire (m); (or desired smoke clear height)

zo = height of the virtual origin above the base of the fire (if below the base of fire, zo is negative) (m);

D = instantaneous fire diameter (m);

To = indoor temperature (°C);

Ts = average temperature of smoke layer (°C);

m = mass production rate of smoke when plume at height z (kg/sec);

V = volumetric smoke production rate (m³/sec);

d =smoke layer depth (m);

Temperature and visibility are two critical criteria for tenability analysis for performance based assessments. In our project experience, the visibility results (i.e. smoke layer thickness for smoke with visibility of 10m or less) from CFD modelling are often more onerous than the results calculated using empirical equations. However, the temperature of smoke layer prediction from CFD matches well with smoke layer calculated from empirical equation. We have conducted a number of investigation and we have pinned this down to a number of reasons, we have chosen two elements, i.e. the weight-average method in developing soot yield and the soot yield deposit which is not currently included in the most CFD model.

Description of Issues:

Based on our project experience in adopting CFD for predicting smoke spread in fire, we propose to conduct a further investigation into the issue of soot yield prediction and deposition in CFD modelling.

Firstly, the basic of visibility prediction by CFD model often follow the empirical equations.

For flaming combustion of wood or plastics:

K = 7.6 × 103 ms Eqt(8)

For a fire burning at rate R (kg·s–1) for a duration t (s), ms is given by:

ms= Ysmoke R t / Vs Eqt(9)

S = 8 Vs / (7.6 × 103 Ysmoke R t) Eqt(10)

where

K: extinction coefficient (m–1) and ms is the mass concentration of smoke aerosol (kg·m–3).

Ysmoke: the yield of smoke particles (kg·kg–1) and Vs is the volume of smoke (m3).

C: non dimensional constant characteristic of the type of object being viewed through the smoke, i.e. C = 8 for a light-emitting sign and C = 3 for a light-reflecting sign.

S: Relative Visibility (m)

The above equations show that the yield of smoke particles (soot yield) is the major factor affecting the resulted visibility. Soot yield is one of the critical input data of CFD model. In general, most of the CFD software can only cater for single combustible reaction. The combustible considered in the analysis of our projects usually is a composition of several different materials.

1. Soot Yield Value Assessment Methodology for Composite of Combustible

In practice, the soot yield inputted to CFD model is usually calculated by the weight-averaging of the soot yield values of the involved materials. The more onerous visibility results shown in CFD model may be due to simplistic assumption of weight-averaging method, especially when the combustible contains synthetic fibre. Another calculation method of soot yield value as input to CFD model may be necessary. This will require derivation of equations or computer programme basing on mathematics and chemistry knowledge.

2. Soot Yield Deposition

Large numbers of validation tests for CFD softwares have been conducted by different organizations throughout the world, such as the VTT tests [4]. One of the common limitations of CFD softwares for predicting visibility is that soot loses due to deposition on affected surfaces (such as ceilings and walls) are not well quantified in the CFD model.

Development of numerical methodology for assess the soot loses due to deposition will be needed to improve the capacity of CFD modelling technique.

Reference:

[1] NFPA 92B Guide for Smoke Management Systems in Malls, Atria, and Large Areas, 2009 edition, National Fire Protection Association, Quincy, MA, USA, 2009.

[2] NFPA 204 Standard for Smoke and Heat Venting, 2007 edition, National Fire Protection Association, Quincy, MA, USA, 2007.

[3] CIBSE Guide E, Fire Engineering, 2nd Edition, Chartered Institution of Building Services Engineers, London, UK. September 2005.

[4] VTT Working Papers 66, Experimental Validation of the FDS Simulations of Smoke and Toxic Gas Concentrations, Tuomo Rinne, Jukka Hietaniemi and Simo Hostikka

Modelling PWM control of a single phase induction motor

Organization: *Interactive Systems & Technologies Limited, Hong Kong*

Presenter: *Dr. Marcus Chau*

E-mail: *mchau@isystemtech.com*

Abstract:

Variable frequency drive (VFD) is a common method to control the rotational speed of an AC induction motor by adjusting the frequency of the supply voltage. One approach to implement VFD is to use Pulse Wide Modulation (PWM) technique. In addition to the rotational speed, there are also other operational parameters such as start-up torque, spin-up time, and energy efficiency to consider. The proposed project is to develop a model of single phase induction motor and PWM control schemes to optimize the motor operational characteristics.

Objectives:

The project aims to develop PWM based schemes to control single phase AC induction motor to operate at different rotational speed with optimized motor performance in terms of:

1. High torque output, particularly during start-up;
2. High energy efficiency; and
3. Shortest spin-up time.

Introduction:

Pulse Width Modulation (PWM) techniques is commonly used in a variable frequency drive scheme to control the rotational speed of an induction motor. The voltage amplitude and the effective frequency of the power supply are obtained by modulating the duty cycle of a pulse train. The basic PWM control principle is the Volt/Hertz ratio which reflects the inductance properties of the motor windings. Other than the rotational speed, the basic scheme has no provision to influence the motor performance characteristics; the output torque, spin-up time and energy efficiency remain fixed parameters of the motor design.

There are also vector control methods based on controlling both the magnitude and the phase of the motor current and voltage to achieve better motor performance, such as smooth motion at slow speed and efficient operation at high speeds. The phase of the current (relative to the applied voltage) governs the 'slip' of the motor, which is related to the output torque. To implement vector control, the spatial angular position of the rotor flux inside the motor and the rotational speed need to be determined. This requires additional sensing hardware components.

An interesting question is whether it is possible to control the phase of the motor current (relative to the applied voltage) by varying the PWM waveform applied to the motor, without having to know the orientation of the rotor flux linkage and the position of the rotor. To answer this question, a mathematical model for analyzing the motor behavior needs to be developed. If the answer to the question is positive, the model will be used to investigate variation on the basic PWM schemes to achieve optimal motor performance

Regime Changes in Non-Stationary Time-Series

Organization: *Mapleridge Capital Corporation, Toronto, Canada*

Presenter: Yunchuan Gao

E-mail: ygao@mapleridgecapital.com

Introduction:

A stationary process is a stochastic process whose joint probability distribution is invariant under time translation; a stationary time-series is an outcome of a stationary process.

Financial data is certainly not stationary; invariance under time-translation is violated by such effects as volatility-clustering and seasonality.

We wish to understand financial time-series data by modeling it by a multi-regime stochastic process, in which the time-series throughout each regime is generated by a stationary process and the transitions between regimes are so- called `change points'.

The question which occurs most often when considering regime changes is `What is the difference between two regimes? What has changed?'. The def-inition above makes it possible that anything could have changed but let us consider some concrete examples:

1. Consider a stock price process, the simplest and most apparent regime change would be a change in the direction of price changes. E.g. the price tended to go up and then it tends to go down.
2. Also on the example of the stock price process we might observe a sudden change in the volatility of the returns (we believe this type of regime change is extremely common). More generally we might consider changes in the distribution, incorporating mean, variance and higher moments, of the returns at some point.
3. If we believe the processes that generate this sort of financial data is not necessarily an independent return process, we may also detect regime changes where the auto-correlation structure of the returns has changed. More generally we might consider changes in process dynamics, such as a tendency to trend to a tendency to reverse.
4. If we consider a basket of stock prices. We might observe regime changes within the correlation matrix of the stock prices.

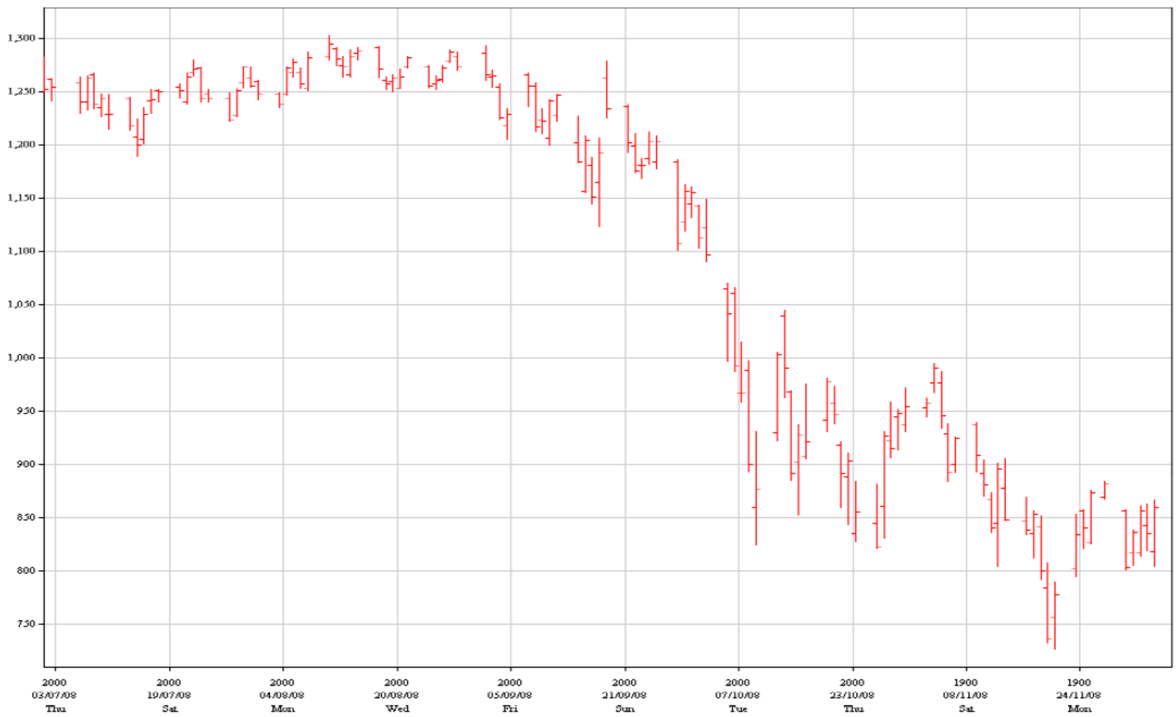

Figure 1: SP 500 Futures Prices during the credit crunch, was there a regime change at this time?

Approaches

There are several approaches to this problem of varying sophistication and complexity. The simplest way to detect a single change point in an independent return process would be to measure the likelihood of each point in the time-series being a change point by performing a statistical test (such as the Kolmogorov-Smirnov test) on the data to the left and right of that point. The most likely candidate point could then be accepted or not as the change point.

This method has several drawbacks:

1. This can only detect changes in the distribution and will not detect changes in auto-correlations, what tests are available to detect more general changes.
2. How do we move on to detecting 2 or more change points when the brute force method of testing each multi-dimensional change point configuration seems intractable? It may be possible to start with detecting a single change point (or at least candidates of such) and then moving on to detecting further change points by analysing each regime. It is not clear, though, that any optimal partitioning of the data with 2 change points, say, is *reducible* to the optimal partioning of the data with 1 change point.

If the number of change points is known beforehand then the most powerful method is to use a hidden Markov model (HMM) to determine the most likely location of those change points. The topology of the HMM is constrained to only allow `right-left' transitions, so that the transition matrix is of the form:

$$\begin{vmatrix} 1-p_{1,2} & p_{1,2} & 0 & \dots & 0 \\ 0 & 1-p_{2,3} & p_{2,3} & \dots & 0 \\ \vdots & & \ddots & & \vdots \\ 0 & \dots & \dots & 1-p_{n-1,n} & p_{n-1,n} \\ 0 & \dots & \dots & 0 & 1 \end{vmatrix}. \qquad (1)$$

The process associated with each state is essentially arbitrary; as long as each can be optimised using maximum likelood, the entire HMM can be optimised using a backwards-forwards (Baum-Welch) algorithm. Once optimised, the HMM and the orignal dataset can be used to obtain a joint probability distribution for the location of the change points. Most practical applications of HMMs use state processes that are iid, most usually a mixed Guassian model, while a simple histogram could be used as a non-parametric model. Yet, there is no reason why this process cannot be an ARMA or other non-iid process. Such would allow modeling of changes in auto-correlation structure.

Problems:

A major problem is that we do not know how many change points a given sequence has. Simply maximizing the likelihood leads us to a model with as many change points as data points, in which the data set is described exactly but provides us with no understanding of the process or its generalities. We see three approaches to addressing this problem

1. A bottom-up approach, in which a single change point is detected and then subsequent change-points are added until no other significant change point can be added. This approach would require a full understanding and resolution of the reducibility problem.
2. A top-down approach where each point is assumed to be a change point and neighbouring points are coalesced into regimes until no more combinations seem possible. This approach seems powerful at first, however, it must be understood that the definition of a change point depends on the global properties of the time-series, so any test developed to combine neighbouring points would have to be global in nature.
3. An extension of the HMM approach, in which the topology of the transition matrix is 'optimised'. How this is acheived is not entirely clear. Two methods have occurred to us. The first is to introduce some penalty function associated with the topology and then maximize likelihood minus penalty, the penalty could (should?) be inspired by an information-theoretic description. The second approach is to apply a method like simulated annealing in a top-down or bottom-up methodology.

We would like the students to break into three groups, with each group assessing and extending one of the above approaches, including: addressing each approach's specific concerns, furthering the analytic understanding of the problem and working towards practical algorithms. The groups should then share ideas and developments between themselves and work towards a final assessment of the utility, power, drawbacks and pitfalls of the different approaches. Of course, we may be overlooking something in our outline of this problem and if during the workshop a radically different approach is considered we would very much like to hear about it.

References:

[1] Rabiner Lawrence R., A tutorial in hidden Markov models and selected applications in speech recognition, fellow, IEEE

[2] Fwu, J.-K. and Djuric P.M. Automatic segmentation of piecewise constantsignal by hidden Markov Models, Proceedings of 8th IEEE Signal Processing Workshop on Statistical Signal and Array Processing. Jun 1996 283-286

[3] Gales, Mark and Young, Steve, The theory of segmental hidden Markov models, Technical Report CUED/F-INFENG/TR Cambridge University Engineering Department (1993) 133

[4] Gereneser, L. Molnar-Saska, G., Change detection of hidden Markov models, Decision and Control, 2004. CDC. 43rd IEEE Conforence on 2 (2004) 1754-1758

[5] Hawkins, M., Point estimation of the parameters of precewise regression models Applied Statistics 25(1) (1976) 51-57

[6] Koop, Gary M. and Potter, Simon M. Forecasting and estimating multiple change point models with an unknown number of change points Federak Reserve Bank of New York Staff Reports

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Local Guide

Having meals on campus and at Festive Walk:

A campus directory is provided for your reference.

City Express canteen (self-served), 5/F, Amenities Building

7:45 a.m. - 9:00 p.m. (Mon - Sun)
A variety range of food at very reasonable price is available, such as dim sum, short orders, set meal, health food, Japanese food, daily carving and bakery products.

City Chinese Restaurant, 8/F, Amenities Building

11:00 a.m. - 11:00 p.m. (Mon - Fri) and 9:00 a.m. - 11:00 p.m. (Sat & Sun)
Full table service with Chinese menu is available at this restaurant.

City Top, 9/F, Amenities Building

11:00 a.m. - 11:00 p.m. (Mon - Sun)
Full table service with western menu and buffet lunch is available at this restaurant.

Festival Walk

A shopping guide of Festival Walk is provided for your easy reference.

Coffee/tea, welcome reception and banquet of the Workshop

Please refer to the schedule of this programme for timetable of these services.

In case of emergency

University Security Office (day & night)	2788-8888
University Health Centre (office hours)	2788-8022
Emergency hotline (for ambulance, fire service, and police)	999

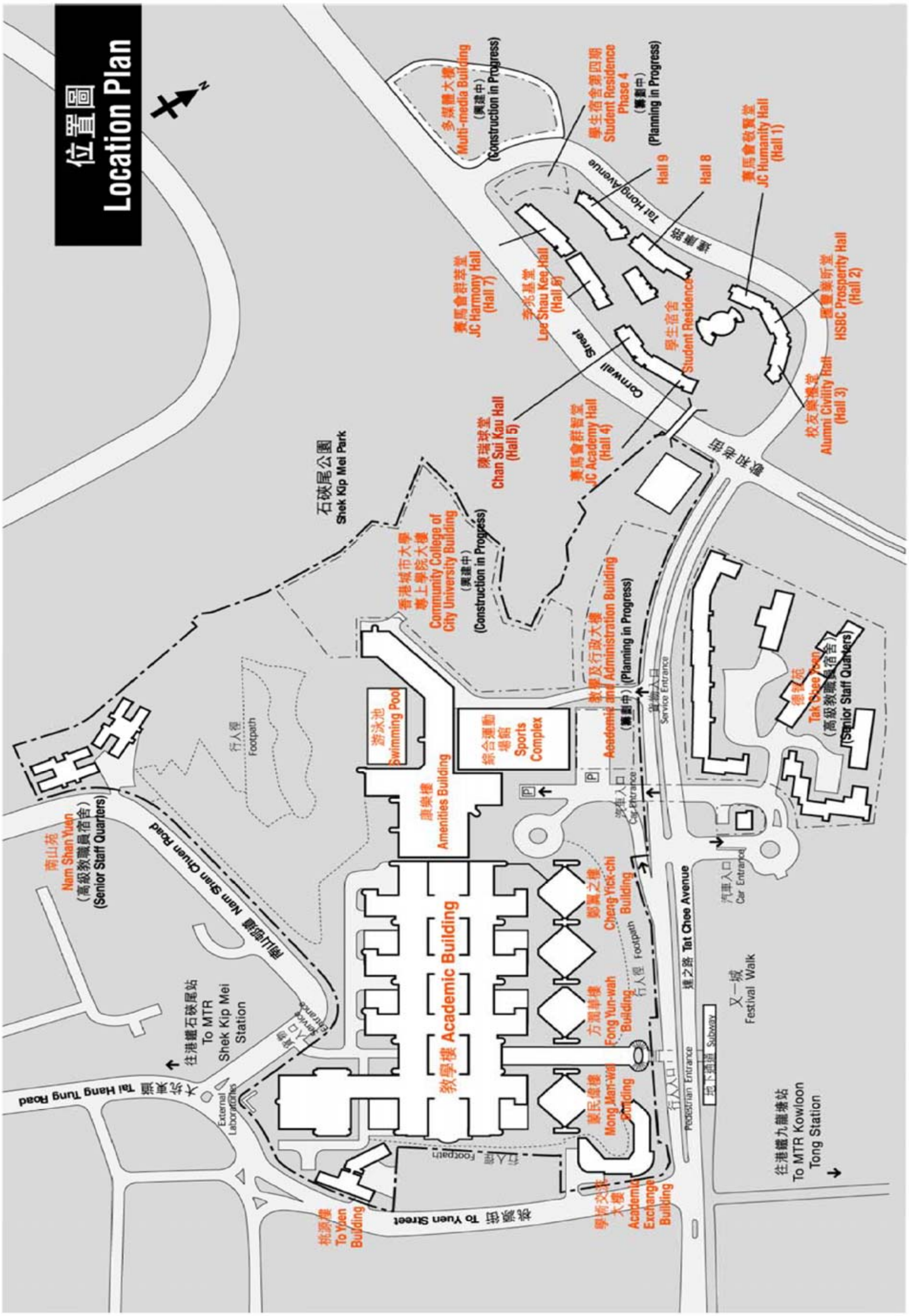
Telephone, fax and internet service

Telephone and fax service may be made through the Department of Mathematics (Tel: 2788-8646; Fax: 2788-8561). Internet service is available in Workshop discussion rooms and MA Laboratory at room Y6504, 6/F, Academic Building.

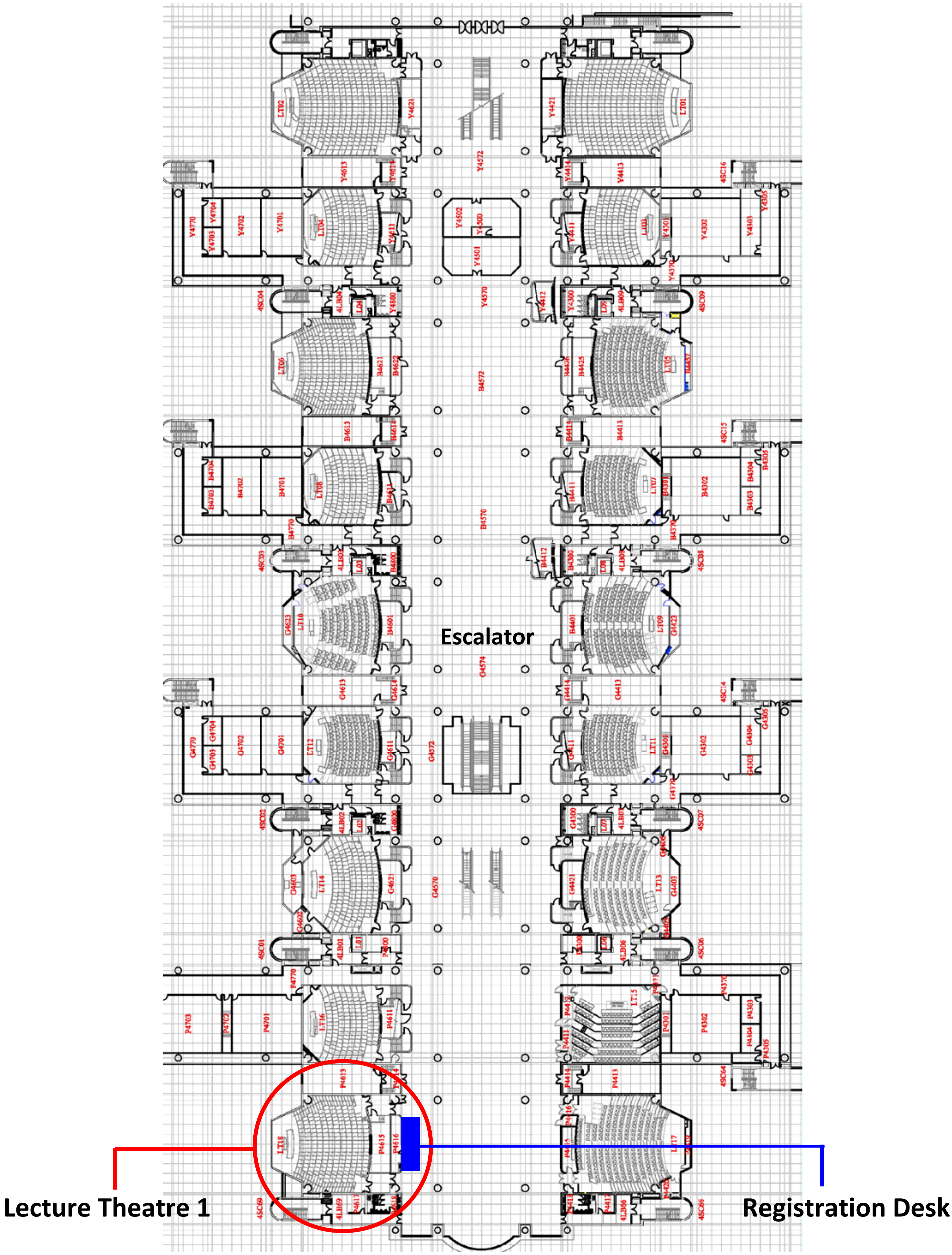
Banking

An Automated Teller Machine (ATM) and a Hang Seng Bank can be found on 3/F, Academic Building.

Map


CityU Campus
位置圖
Location Plan
N
石硤尾公園
Shek Kip Mei Park
教學樓 Academic Building
康樂樓
Amenities Building
游泳池
Swimming Pool
Sports Complex
Academic and Administration Building
(Planning in Progress)
Community College of City University Building
(Construction in Progress)
Multi-media Building
(Construction in Progress)
Student Residence Phase 4
(Planning in Progress)
Hall 9
Hall 8
JC Humanity Hall
(Hall 1)
HSBC Prosperity Hall
(Hall 2)
Alumni Civility Hall
(Hall 3)
JC Academy Hall
(Hall 4)
Chan Sui Kau Hall
(Hall 5)
Lee Shau Kee Hall
(Hall 6)
JC Harmony Hall
(Hall 7)
學生宿舍
Student Residence
Tak Chee Yuen
(Senior Staff Quarters)
南山苑
Nam Shan Yuen
(Senior Staff Quarters)
Nam Shan Chuen Road
Tai Hang Tung Road
To Yuen Street
Tat Chee Avenue
Cornwall Street
Tat Hong Avenue
Cheng Yick-chi Building
Fong Yun-wah Building
Mong Man-wai Building
Academic Exchange Building
To Yuen Building
External Laboratories
Footpath
Car Entrance
Service Entrance
Pedestrian Entrance
Subway
又一城
Festival Walk
To MTR Shek Kip Mei Station
To MTR Kowloon Tong Station

Venue Map, 4/F Academic Building



Plan of the 5th Floor