# The 2nd
# Workshop on Industrial Applications

City University of Hong Kong
Hong Kong

**December 4 - 8, 2006**

## Workshop Guide

Web site: http://www.cityu.edu.hk/rcms/WIA2006/

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# Introduction

This is the second *Workshop on Industrial Applications* held at City University of Hong Kong from December 4 - 8, 2006.

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 three 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 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., appreciated this unique opportunity to share their research experience with experts from the United Kingdom, Canada and Australia.

The Second Workshop on Industrial Applications aims to stimulate collaboration between industry representatives and applied mathematicians. Industry representatives will present problems on the first day of the workshop followed by small group discussion on the next three days. The result will then be presented on the final day.

This event will encourage the greater use of mathematical modeling and analysis in industry and provide a unique opportunity for applied mathematicians to be exposed to industrial problems.

# Organizing Committee

### Advisors

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Roderick Wong, City University of Hong Kong

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Gerard Tronel, Université Pierre et Marie Curie, France
Yanbo Wang, Fudan University, P. R. China
Ting Wei, Lanzhou University, P. R. China

# Industry Representatives

| | |
|---|---|
| **Government:** | Hong Kong Observatory |
| **Utility:** | CLP Power Hong Kong Ltd.;<br>Huizhou Electric Power, P. R. China |
| **Finance:** | Reuters Hong Kong Ltd. |
| **Hi-tech:** | SAE Magnetics (HK) Ltd. |
| **Manufacturing Engineering:** | Nippon Steel Co., Japan |
| **Environmental:** | Inspecting Station of Geology and Environment in Zibo, Shandong, P. R. China |

# Workshop Programme

Updated schedule information may be posted outside lecture theatre LT-3, Academic Building.

## December 4, 2006 (Monday)

| | | |
|---|---|---|
| 9:00am – 9:15am | **Registration** | LT-3 |
| 9:15am – 9:30am | **Opening Ceremony** | LT-3 |
| *Morning session: 9:30am – 12:30pm* | *Chair: Huihui Dai* | |
| 9:30am – 10:00am | Presentation by Hong Kong Observatory | LT-3 |
| 10:00am – 10:30am | Presentation by CLP Power Hong Kong Ltd. | LT-3 |
| 10:30am – 11:00am | Coffee Break | |
| 11:00am – 11:30am | Presentation by Reuters Hong Kong Ltd. | LT-3 |
| 11:30am – 12:00noon | Presentation by SAE Magnetic (H.K.) Ltd. | LT-3 |
| 12:00noon – 1:30pm | Lunch Break | |
| *Afternoon session: 1:30pm – 3:00pm* | *Chair: Daniel W. C. Ho* | |
| 1:30pm – 2:00pm | Presentation by Nippon Steel Co., Japan | LT-3 |
| 2:00pm – 2:30pm | Presentation by Inspecting Station of Geology and Environment in Zibo, P. R. China | LT-3 |
| 2:30pm – 3:00pm | Presentation by Huizhou Electric Power, P. R. China | LT-3 |
| 4:15pm – 6:00pm | Welcome Reception<br>at 9/F, Amenities Building,<br>City University of Hong Kong | |

## December 5, 2006 (Tuesday)

| | | |
|---|---|---|
| 9:30am – 12:00noon | **Work on Problems** | |
| | The automatic determination of atmospheric visibility from real-time images of video cameras | Y5-101 |
| | Optimal tariff period determination | Y5-102 |
| | An alternative to Black-Scholes: pricing options with artificial intelligence | Y5-103 |
| *10:30am – 11:00am* | | |
| *Coffee Break* | Etch rate prediction for Ion milling machine | Y5-104 |
| *outside Y5-205* | | |
| | How is a hidden rule found from operation data? | Y5-202 |
| | Mathematical models for undisturbed soil-column experiments | Y5-203 |
| | Power load forecasting | Y5-204 |
| 12:00noon – 1:30pm | Lunch Break | |
| 1:30pm – 5:30pm | The automatic determination of atmospheric visibility from real-time images of video cameras | Y5-101 |
| | Optimal tariff period determination | Y5-102 |
| | An alternative to Black-Scholes: pricing options with artificial intelligence | Y5-103 |
| *3:00pm – 3:30pm* | | |
| *Coffee Break* | Etch rate prediction for Ion milling machine | Y5-104 |
| *outside Y5-205* | | |
| | How is a hidden rule found from operation data? | Y5-202 |
| | Mathematical models for undisturbed soil-column experiments | Y5-203 |
| | Power load forecasting | Y5-204 |

## December 6, 2006 (Wednesday)

| | | |
|---|---|---|
| 9:30am – 12:00noon | **Work on Problems** | |
| | The automatic determination of atmospheric visibility from real-time images of video cameras | Y5-101 |
| | Optimal tariff period determination | Y5-102 |
| *10:30am – 11:00am* | An alternative to Black-Scholes: pricing options with artificial intelligence | Y5-103 |
| *Coffee Break* | Etch rate prediction for Ion milling machine | Y5-104 |
| *outside Y5-205* | How is a hidden rule found from operation data? | Y5-202 |
| | Mathematical models for undisturbed soil-column experiments | Y5-203 |
| | Power load forecasting | Y5-204 |
| 12:00noon – 1:30pm | Lunch Break | |
| 1:30pm – 5:30pm | The automatic determination of atmospheric visibility from real-time images of video cameras | Y5-101 |
| | Optimal tariff period determination | Y5-102 |
| | An alternative to Black-Scholes: pricing options with artificial intelligence | Y5-103 |
| *3:00pm – 3:30pm* | Etch rate prediction for Ion milling machine | Y5-104 |
| *Coffee Break* | How is a hidden rule found from operation data? | Y5-202 |
| *outside Y5-205* | Mathematical models for undisturbed soil-column experiments | Y5-203 |
| | Power load forecasting | Y5-204 |
| 7:00pm – 9:00pm | Banquet[#] | |

[#] Banquet tickets are available at the workshop counters (HK$350 per person) which are:

- outside lecture theatre LT-3 (December 4 and 8, 2006)
- outside Y5-205 (December 4, 6 and 7, 2006)

## December 7, 2006 (Thursday)

| | | |
|---|---|---|
| 9:30am – 12:00noon | **Work on Problems** | |
| | The automatic determination of atmospheric visibility from real-time images of video cameras | Y5-101 |
| | Optimal tariff period determination | Y5-102 |
| *10:30am – 11:00am* | An alternative to Black-Scholes: pricing options with artificial intelligence | Y5-103 |
| *Coffee Break* | Etch rate prediction for Ion milling machine | Y5-104 |
| *outside Y5-205* | How is a hidden rule found from operation data? | Y5-202 |
| | Mathematical models for undisturbed soil-column experiments | Y5-203 |
| | Power load forecasting | Y5-204 |

## December 8, 2006 (Friday)

| | | |
|---|---|---|
| *First session: 9:30am – 10:30pm* | *Chair: Huihui Dai* | |
| 9:30am – 9:45am | Presentation to Hong Kong Observatory | LT-3 |
| 9:45am – 10:00am | Presentation to CLP Power Hong Kong Ltd. | LT-3 |
| 10:00am – 10:15am | Presentation to Reuters Hong Kong Ltd. | LT-3 |
| 10:15am – 10:30am | Presentation to SAE Magnetic (H.K.) Ltd. | LT-3 |
| 10:30am – 11:00am | Coffee Break | |
| *Second session: 11:00am – 12:00noon* | *Chair: Daniel W. C. Ho* | |
| 11:00am – 11:15am | Presentation to Nippon Steel Co., Japan | LT-3 |
| 11:15am – 11:30am | Presentation to Inspecting Station of Geology and Environment in Zibo, P.R. China | LT-3 |
| 11:30am – 11:45am | Presentation to Huizhou Electric Power, P.R. China | LT-3 |
| 11:45am – 12:00noon | **Closing Remarks** | LT-3 |

# Industrial Problems

## The automatic determination of atmospheric visibility from real-time images of video cameras

Organization: *Hong Kong Observatory*

Presenter: *K.H. Tam*

E-mail: *khtam@hko.gov.hk*

"Visibility" is defined as the greatest distance at which a black object of suitable dimensions, located near the ground, can be seen and recognized when observed against a scattering background of fog, sky, etc. This definition is based on human observation of atmospheric visibility conditions.

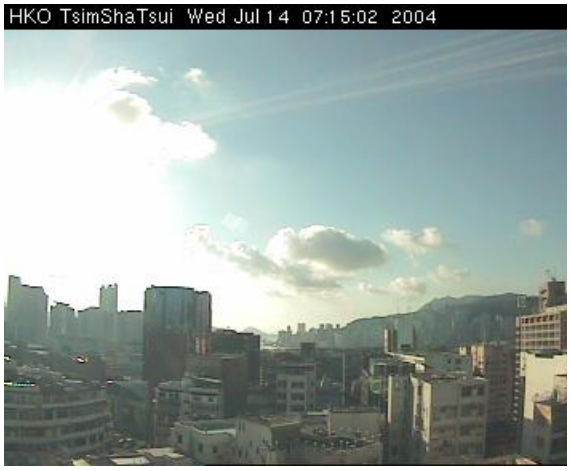
Instrumental observations of visibility are based on measurements of attenuation of light due to both scattering and absorption by particles in the air along the path of a light beam or by measuring the scatter coefficient of light within a volume of air. Both methods have their limitations as only a small volume of air is sampled in the determination of visibility and may produce large errors when the source of reduction in visibility is far away from the sampled air volume.

Nowadays, video cameras are widely used for remote monitoring and security surveillance purposes. Visibility estimation using digitized video images through identification of targets at known distance from the camera is a potential application. It has an intrinsic advantage over the instrumental light-absorption/scattered approaches in that the image acquisition processes between the camera lens system and the human eye are similar.

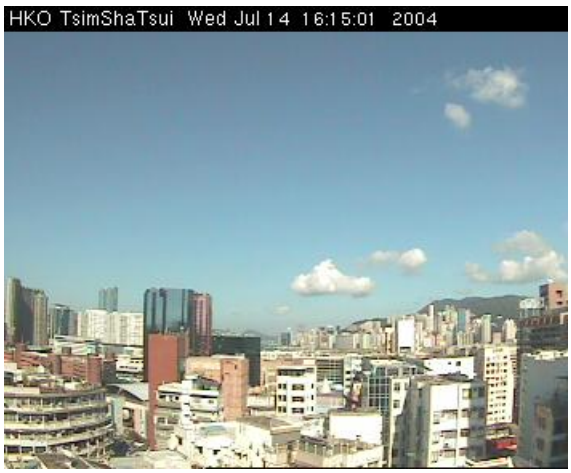
The use of images from video cameras for the automatic observation of visibility is non-trivial. The determination of visibility from images is affected by the size and shape of the reference targets, the contrast of the targets and their background and weather conditions (see attached photos). The objective of this research topic is to develop an efficient automatic algorithm to compute visibility through the processing of images captured by video cameras.


1(a) Photo with good contrast showing clearly distant hills that are over 20 km away


1(b) Photo of the same view but with reduced visibility. A small island on the top right corner of the photo is just barely seen.




2(a) Photo affected significantly by the backlight caused by the morning sun




2(b) Photo of the same place captured in the afternoon on the same day, with good contrast for the landmarks

# Optimal tariff period determination

Organization: *CLP Power Hong Kong Limited*

Presenter: *Jeffrey Leung*

E-mail: *Jeffrey@clp.com.hk*

Cost of electricity generation is closely related to system demand. In general, the generation cost is higher during system peak period, and vice versa. In Hong Kong, power system usually reaches its daily loading peak in the daytime during operating hours of commerce and industry, and drops to the cave after midnight (see figure 1). The loading requirement is also seasonal related in which summer load is higher than winter load (see figure 2).

One of our objectives in tariff setting is giving signal to customers the time variant cost of supplying electricity. Since the costs of supply vary continuously, the ideal would be charging in real-time rate. However, this may not be practical due to metering and billing constraints, the cost involved and also because most customers would not understand this form of pricing.

A more cost-effective solution would be periodic rate. Hours are grouped into a practical number of rating periods. Following constraints are necessary in the rating period selection process in order to ensure an acceptable compromise between implementation limitations (billing, metering), true cost reflectivity, and customer acceptance.

(a) 2 seasons – winter and summer.

(b) 3 (possibly 4) rating periods per season – critical peak, peak, shoulder and off peak.

Within the stated constraints, the tariff period selection process entails determining optimum break points between the 2 seasons, as well as the 3 or 4 rating periods, from a cost reflectivity point of view. Breakpoints are also expected to be different depending on the characteristics of system load e.g. day or night peak, summer or winter peak. All these are needed to be taken into account in the rating period selection process.

Problems raised:

1. What is the best method to determine the optimal break points?
2. What is the ideal period setting?

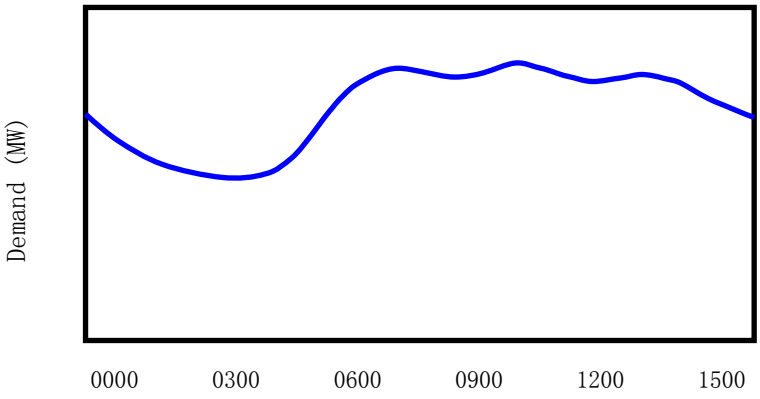



Figure 1. Typical Daily Demand Profile

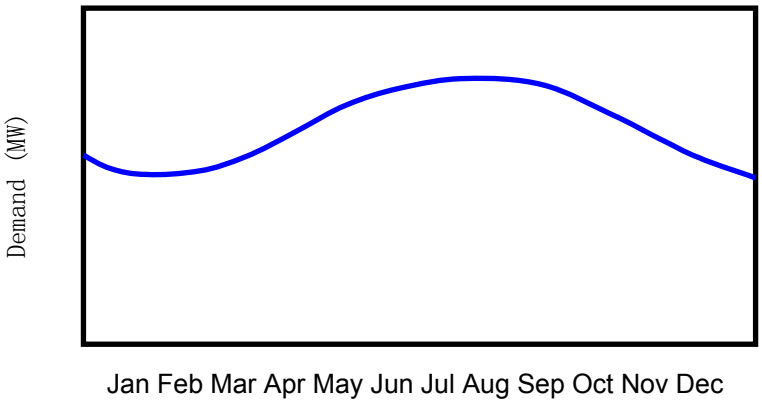



Figure 2. Typical Annual Demand Profile

# An alternative to Black-Scholes: pricing options with artificial intelligence

Organization: *Reuters Hong Kong Ltd.*

Presenter: *Steven Cheung*

E-mail: *steven.cheung@reuters.com*

Trading and stock markets have been extensively using Black-Scholes formulae to price European options which was originated from the seminal papers of Black and Scholes (1973) and Merton (1973) with focuses on the following assumptions:

1. Create risk-free portfolios through dynamic hedging so that the portfolios earn risk-free interest rate;
2. Ensure an absence of arbitrage environment (Efficient markets);
3. Ensure no commission;
4. Ensure no interest rate change; and
5. Assume that stock returns follow a lognormal distribution.

However, in the real world commissions do exit and interest rates can change. Whether markets are efficient or not is still debatable. Furthermore, volatility smile has proven that stock returns and foreign exchange markets do not follow a lognormal distribution. Since Black-Scholes formulae relies on these questionable underlying assumptions, an alternative approach should be considered. Recently, artificial intelligence technology has been applied to develop an option pricing system to adjust itself to dynamic environments with no underlying assumption. The idea was originated from the works of Hutchinson, Lo and Poggio (1994) and Malliaris and Salchenberger (1993). For instances, the use of neural networks [1] and genetic algorithms [2, 3] gives the following neural network equation to price options:

$$f(X,w) = \sum_{h=1}^{H} \beta_h g\left( \sum_{i=0}^{I} \gamma_{hi} x_i \right)$$

where $\beta$ and $\gamma$ are the weight arrays of the neural network, g(.) is a non-linear transfer function attached to each hidden unit, and the input parameters for this neural network are stock price (S), strike price (X), interest rate (r), time to maturity (T-t) and historical volatility $\sigma_{30}$ (30 days volatility).

Similar system was discussed in [4] with Figure 1 as the graphical representation.

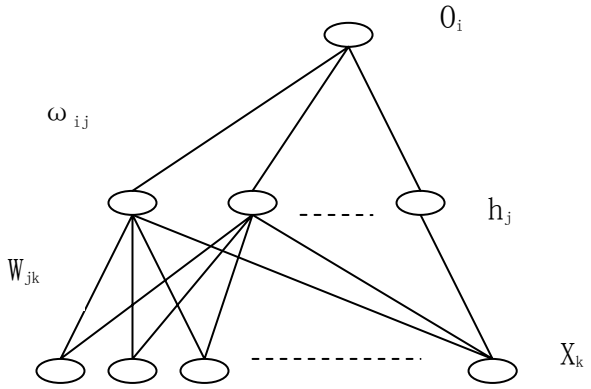



Figure 1. A single hidden layer Multi-Layer Perception (MLP) architecture.

There are several methods to measure performance. For examples, the measures of square correlation between the actual and computed prices (R2), mean deviation (MD), mean absolute deviation (MAD), mean proportionate deviation (MPD) and mean square deviation (MSD). Greek letters such as Delta, Gamma, Theta and Vega are also very useful indicators on the performance.

Questions:

1. How to improve the non-linear transfer function g(.) so that it can be effectively used to price options at low computation complexity?
2. Can the neural network be extended to price American option?
3. Can the neural network be extended to price dividend paying stock options, currency and future options? What are the limitations of the models?

Reference:

[1] Julia Bennell and Charles Sutcliffe, “Black-Scholes versus Artificial Neural Networks In Pricing FTSE 100 Options”, Intelligent Systems in Accounting, Finance and Management, 12, 243-260, 2004.

[2] Shu-Heng Chen, Wo-Chiang Lee and Chia-Hsuan Yeh, “Hedging Derivative Securities with Genetic Programming”, International Journal of Intelligent Systems in Accounting, Finance & Management, 8, 237-251, 1999.

[3] Ulrich Anders, Olaf Korn and Christian Schmitt, “Improving the Pricing of Options: A Neural Network Approach”, Journal of Forecasting, 17, 369-388, 1998.

[4] Henrik Amilon, “A Neural Network versus Black-Scholes: A Comparison of Pricing and Hedging Performances”, Journal of Forecasting, 22, 317-335, 2003.

# Etch rate prediction for Ion milling machine

Organization: *SAE Magnetic (H.K.) Ltd.*

Presenter: *Toby Choi*

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SAE is producing writing/reading heads for computer hard disk. This heads are tiny parts which are fabricated from a wafer. Etching is one of the important process in which a desired pattern on head is obtained. The etching process is performed in an Ion milling machine. To control the pattern depth, we need to predict the etch rate of the machine.

Until now, we know some factors are affecting the etch rate.

1. Number of wafer
   One ion milling machine can process up to four wafers at a time. To our understanding, during the etching process, the sub-product produced will hinder the process; therefore, if there are more wafer inside the process chamber, the more sub-products will be formed.
2. Type of wafer
   We process different kind of wafer in working days randomly. Those wafers are different in material, hardness etc. This will affect the etch rate.
   Some of the factors are embedded in “type of wafer”, for example, voltage and power and other tangled electrical setting, they are default by type of wafer.
3. Type of gas
   We use different media in etching. Argon and oxygen are most common which give different performance.
4. Direction of ion beam
   The incidence angle of the ion beam is different in terms of wafer type, for example 30 deg and 60 deg. The etch rate will be different.
5. Working time / Idle time / Periodic maintenance
   a. As mentioned in 1), sub-product is produced in the chamber, the longer the machine is in operation, the larger amount of sub-product is accumulated in the chamber. This factor is not sure because some cleaning procedure is proceeded after etching.
   b. If the machine is not in operation for a couple of hours, it takes some time to “warm up”. We do not know the actual cause but it is sure that the etch rate is most unstable after long time idle.
   c. We need to do a full check and maintenance every 6000 minutes of operation. Etch rate is most difficult after this maintenance.

# How is a hidden rule found from operation data?

Organization: *Nippon Steel Company, Japan*

Presenter: *Junichi Nakagawa*

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Steel company researchers tend to focus on manufacturing processes. The phenomena are mostly complex, however, observations are limited because we must operate with high temperature objects and large-scale equipment. Consequently, we have been trying to find hidden rules from operation data.

For example, we use blast furnaces in the main process of iron making. A blast furnace is a huge reactor with a height of about 40 meters. In this process, sintered ore and coke are sequentially charged from the top of the blast furnace while hot air is blasted from the furnace bottom at a temperature about 1500K. This raises the temperature inside the blast furnace to a high temperature of more than 2700K, thereby accelerating the chemical reaction that separates the iron from the sintered ore.

The temperature, measured with the thermo-couples in a brick, is shown in Figure 1. The section within a dotted frame shows abnormal conditions of operation control; this continued over a two-month period. Shutdown operations were carried out at the times shown by arrows in the figure. In shutdown operations, production of molten iron is suspended for one or two days. Although the primary purpose of shutdown operations is scheduled maintenance, unscheduled shutdown operations were carried out five times to lower the furnace temperature. These are enormously damaging in terms of cost. Why do such abnormal conditions suddenly occur? Is there an effective means of identifying the signs? These are the issues that concern us.

We also show a map representing the position of these phenomena in four categories of the manufacturing process: stationary, non-stationary, linear and nonlinear. Our phenomena fall into the non-stationary and nonlinear category. However, we do not have a method by which this area can be analyzed. If mathematical principals can be applied in this area, we can have direct linkage between real phenomena and mathematics. This will enable reduced costs, and innovation in manufacturing processes.

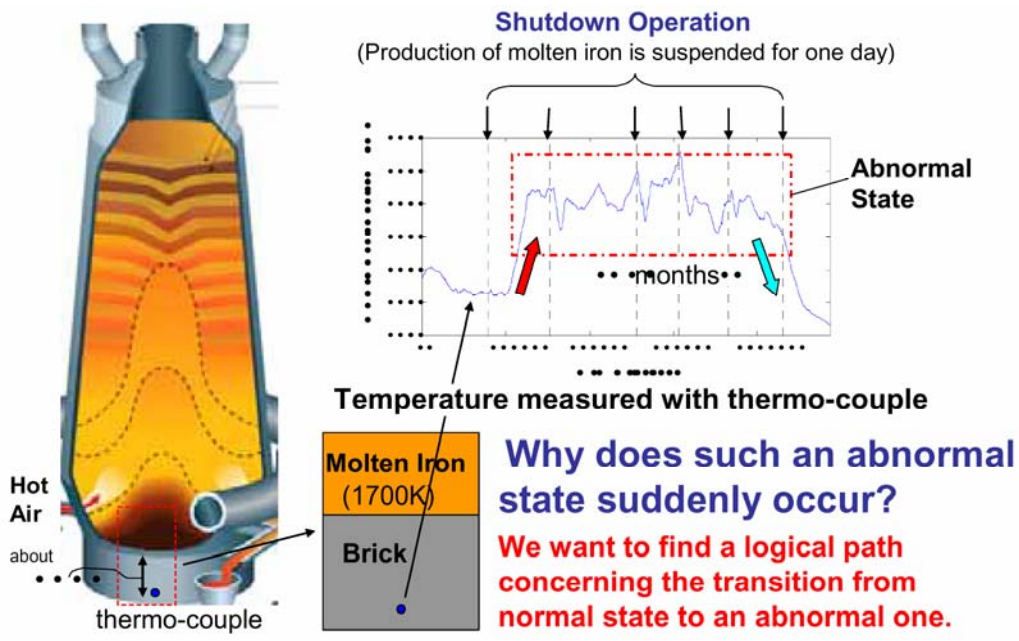


Figure 1 Problem description for blast furnace

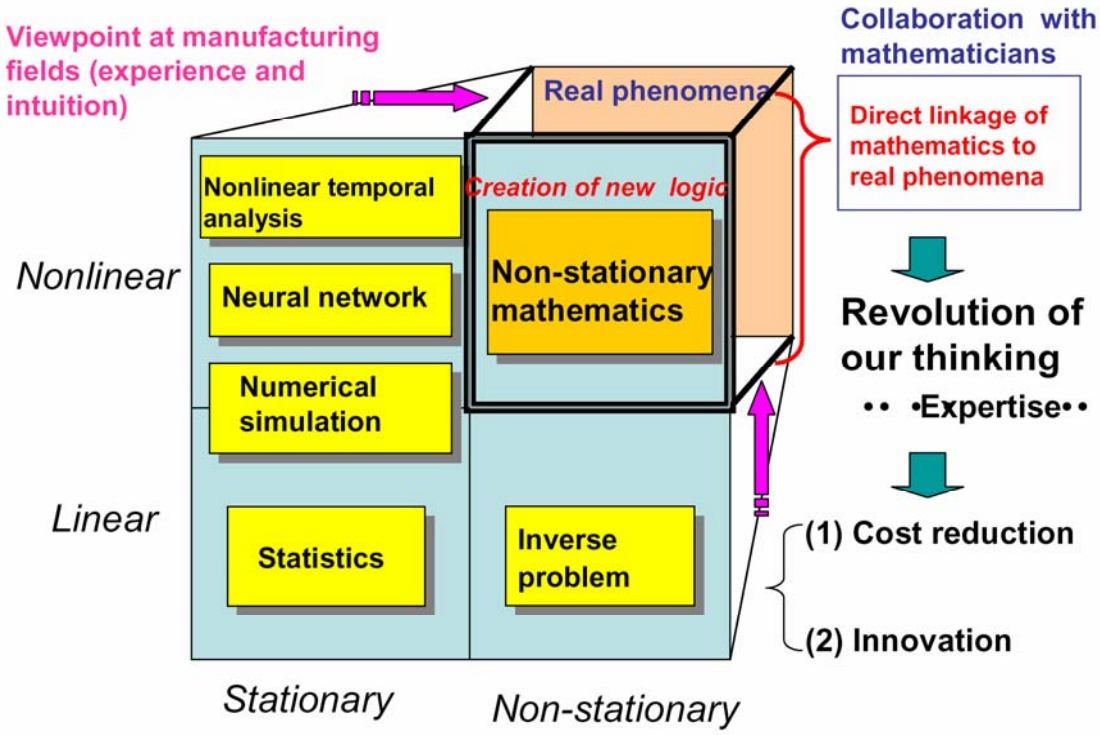


Figure2 Expectation regarding mathematics

# Mathematical models for undisturbed soil-column experiments

Organization:
*Institute of Applied Mathematics, Shandong Univ. of Tech., Zibo, P. R. China*
*Institute of Environment Sci. and Tech., Shandong Univ. of Tech., P. R. China*
*Inspecting Station of Geology and Environment in Zibo, P. R. China*
*Zibo Water Resources Management Office, Zibo, P. R. China*

Presenter: *Gongsheng Li (Shandong University of Technology, P. R. China)*

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When some kinds of pollutants infiltrate into an aquifer, the pollutants need to traverse a zone of unsaturated soil containing liquid, solid and gas. To prevent and remedy any soil and groundwater pollutions, it is important to understand the physical and/or chemical reactions and mechanisms of solute transport in the unsaturated region. An effective way to reveal the process is to perform soil-column experiment.

Consider an actual undisturbed soil-column experiment with sub-clays carried out in Zibo, Shandong Province. From the results of experiment, it had been found that the measured BTCs for main solute ions do not behave as expected increasing curves. The real curves went up rapidly at the initial stage but then came down gradually. The concentration of the initial out-flowing liquor was almost double than the infiltrating flow. As time went on, the solute concentration of the out-flowing became lower, and moved up and down near the initial infiltrating concentration till the end of waste water infiltration. It is obvious that this column experiment demonstrated a nonlinear adsorbing/degrading process which varied with the experimental time between the liquid and the solid phases.

In summary, the pollutants contained in the column dissolved rapidly and nonlinearly at the initial stage. The absorbed capability of the soil increased gradually until the solute transport behaviors arrived at an asymptotical equilibrium.

A problem to be addressed in the Workshop is how to derive an appropriate mathematical model to explain the phenomena observed in the experiment.

# Power load forecasting

Organization: *Huizhou Electric Power, P.R. China*

Presenter: *Zhifeng Hao (South China University of Technology, P. R. China)*

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Power load forecasting can be divided into load forecasting and electrical consumption predicting according to forecasting matter. Base on different predicting time, it can be divided into long-term load forecasting, mid-term forecasting, short-term forecasting and ultrashort-term forecasting. Mid-term and long-term forecasting mainly used in power factory macro control, and their forecasting time ranges are respectively from one month to twelve months and from one month to ten months respectively. The short-term forecasting can be used in generators macroeconomic control, power exchange plan and so on. And the prediction is from one day to seven days in the future, or a little longer time. Whereas the ultrashort-term forecasting can predict the situation in a day or in an hour, and it's mainly used in Prevention and control emergency treatment and frequency control. With the deepen reform of electricity, the formation of power market and the independent and self-financing of electricity enterprises, power load forecasting becomes more and more important. How to improve the accuracy of power load forecasting is a valuable research. Generally speaking, long-term accuracy of the forecast will be lower, while short-term will be higher.

**Problems:**

(1) Combine the economy development (such as GDP) and the feature of the city; predict the total electrical consumption and the peak load of the city in 2006.

(2) Forecast the mensal consumption and mensal peak load in 2006, and amend the prediction value when giving the real consumption of the first three months. (Hint: Affected by the Spring Festival, the conditions of Jan and Feb are special.)

(3) Forecast the daily consumption of July 10th to 16th in 2006 (unit: 10000kw/h) and the daily peak load (unit: 10000kw/h). (Hint: Generally speaking, the electrical consumption of Sunday is the lowest in a week, and the consumptions of Thursday and Friday are higher than others. We also find the consumption will increase as the temperature increase in the summer.)

(4) Forecast load of every 15 minutes of July 10th (unit: 1000kw). We find that there are two peaks, respectively, in the morning and at night, and the consumption is low at noon, while lowest late at night. The load jumping-off point of on Monday is lower, i.e. the load at 0:00-8:00 is clearly lower than other days.

(5) Real time forecasting, i.e. according to the former load, amend the next 15 minutes' load.

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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.