IX MODELLING WEEK UCM

Master in Mathematical Engineering - UCM

Madrid, June 15-19, 2015

http://www.mat.ucm.es/congresos/mweek/

Newsletter
June, 2015

Contents

Welcome

We are delighted to announce the ninth Modelling Week, which will be held from June 15 to June 19, 2015 at the Faculty of Mathematics of Universidad Complutense de Madrid (UCM), Spain.

The IX Modelling Week is organized within the Master Program of the Faculty of Mathematics of UCM in cooperation with the Instituto de Matemática Interdisciplinar (IMI).

The main purpose of the IX Modelling Week is to promote the use of mathematical methods and models in research, industry, innovation, and management in the knowledge economy.

The Modelling Week is open to the students of the Master in Mathematical Engineering at UCM and to participants from other mathematically oriented master programs worldwide.

Students will work in small groups on real industrial problems proposed by companies under supervision of one or two qualified instructors.

The official language of the event is English.

Valeri Makarov
Modelling Week
Director

Marta Arregi
Manager of the Instituto de
Matemática Interdisciplinar

Carlos Calvo
Modelling Week
Collaborator

2. Collaborators, programme, problems, participants

Supported by:

Faculty of Mathematics, UCM

Instituto de Matemática Interdisciplinar

Universidad Complutense de Madrid

Popular

MAPAL software

Attendants and coordinators from:

Faculty of Mathematics, UCM

Instituto de Matemática Interdisciplinar

Universidad Complutense de Madrid

University of Oxford

University of Leicester

Università degli Studi di Firenze

Saratov State University

Problems proposed by:

Popular

University of Oxford

Instituto de Matemática Interdisciplinar

MAPAL software

Gobierno de España, Ministerio de Defensa

INTA Instituto Nacional de Técnica Aeroespacial

MONDAY 15/06/2015. Opening session (open to the public)

Room: Miguel de Guzmán (S118A, floor -1)

- 16:00 - 16:20. Introduction and opening of the IX Modelling Week, UCM
- 16:20 - 16:40. Exposition of Problem 1. Elena Tanarro Santamaría, Banco Popular, Spain
- 16:40 - 17:00. Exposition of Problem 2. Tamsin E. Lee, University of Oxford, United Kingdom
- 17:00 - 17:20. Exposition of Problem 3. Julio Plaza del Olmo, Instituto Nacional de Técnica Aeroespacial, Spain
- 17:20 - 17:40. Exposition of Problem 4. Iker Barriales-Valbuena, Mapal Software, Spain
- 17:40 - 18:00. Exposition of Problem 5. José Antonio Villacorta Atienza, Instituto de Matemática Interdisciplinar, Spain
- 18:00 - 20:30. Working Groups in the laboratories.

TUESDAY 16/06/2015 TO THURSDAY 18/06/2015. Working in groups

Distribution of labs:

- Problem 1: Room Informática 1 (S217A, floor: –2)
- Problem 2: Room Informática 2 (S218, floor: –2)
- Problem 3: Room Informática 3 (S115, floor: –1)
- Problem 4: Room Informática 0 (S217A, floor: –2)
- Problem 5: Room 116 (floor: 1)

Working hours:

- Tuesday 16/06 and Thursday 18/06: 9:00 - 14:00 and 16:00 - 20:30
- Wednesday 17/06: 16:00 - 20:30

FRIDAY 19/06/2015. Closing session (open to the public)

Room: Miguel de Guzmán (S118A, floor -1)

- Morning. Groups at laboratories. Preparing final reports and presentations
- 17:00 - 19:30. Each working group gives a public presentation describing main results
- 19:30. Closing of the IX Modelling Week at the UCM

Faculty of Mathematics, Universidad Complutense de Madrid, Spain.

PROBLEM 1:

Generating a caplet volatility surface

Popular

Proposed by: Banco Popular, Spain

Coordinator: Gerardo E. Oleaga Apadula, Universidad Complutense de Madrid, Spain

Exposition of the problem: Elena Tanarro Santamaría, Banco Popular, Spain

Introduction

In order to effectively calculate the outstanding position held by the bank, there is a need of accurate models as well as valuation inputs.

To achieve this objective, it is necessary to invest a considerable team effort into the investigation of many market metrics, models, and techniques used for the estimation of reliable parameters.

During the last few years, financial markets have suffered great disruption and most of the models and assumptions have been questioned. One of the latest examples is the lognormal assumption of the distribution of the interest rates.

Specifically, the great extent of quoted interest rates very close to zero and negative quoted forward rates has led to a correction of the assumption of lognormality towards the normal distribution.

Here, we propose to study this new assumption and consequences to the economic factors it may imply.

Objective

Valuation models rely on a parametric distribution of the return of the assets. The most common distribution for returns is the normal one, which implies a lognormal distribution for the asset meaning strictly positive values. Years ago, the assumption of positive prices was not questionable but the current level of interest rates has made it necessary to use models that accept negative values. This change of model also implies a change in the volatility input. The problem, outlined in more detail in the next section, focuses its attention on obtaining a caplet volatility surface that combines both an accurate valuation of liquid products (via mark to market valuation) while maintaining smoothness.

Main goals

- Describe the main differences between lognormal and normal Black Scholes valuation formula.
- Implement normal Black Scholes valuation formula for caps and floors.
- Become acquainted with standard formats of data in financial platforms.
- Implement an iterative process to obtain caplet volatility surface from cap volatility surface.
- Discuss smoothness versus accuracy to the issue we are dealing with.
- Evaluate the accuracy of your results comparing them with quoted prices.

PROBLEM 2:

Providing electricity in the future

Proposed by: Oxford Centre for Industrial and Applied Mathematics, United Kingdom

Coordinator: Tamsin E. Lee, University of Oxford, United Kingdom

Exposition of the problem: Tamsin E. Lee, University of Oxford, United Kingdom

Introduction

Electricity demand is rapidly evolving, but the infrastructure delivering our electricity is not. The infrastructure is maintained by Distribution Network Operators (DNOs), who ensure that electricity is delivered reliably and safely.

Traditionally their focus has been on large consumers, such as warehouses. However, it is electricity use on the low voltage (LV) network (domestic and small-to-medium enterprises (SMEs), such as the corner shop) that is changing the most as more and more of our devices require electricity in some way. As we move into a low carbon future there will be further uptake of electric vehicles, fast charging electric vehicles, solar panels and heat pumps. These all contribute to stresses upon an infrastructure which is decades behind the technology it supplies.

In particular, SMEs have:

- fairly high use - considerably higher than domestic customers
- very regular behaviour
- little research into their electricity use

Modelling plan

Possible strategy:

- Identify the open and closed hours for each SME from their electricity profile.
- Find the quarterly meter reading (essentially the daily average use) for each SME.
- Find relationships between average use during open/closed half hours and information available without a smart meter, i.e. survey responses and/or quarterly meter readings. Do buildings of the same age and size have similar electricity profiles?
- Using the discovered relationships, create an approximate profile for an SME. The simplest would take on one value for open half hours and another for closed half hours.
- Focus on peak behaviour - can you provide the time and size of peaks? Perhaps a probability distribution for each half hour?
- What is a suitable way to compare the predicted profile with the actual profile?

Possible techniques:

- Clustering. K-means or finite mixture modelling.
- Probability distributions.

PROBLEM 3:

Homogenization process in nanotechnology and metamaterials

GOBIERNO DE ESPAÑA MINISTERIO DE DEFENSA
INSTITUTO NACIONAL DE TÉCNICA AEROESPACIAL

Proposed by: Instituto Nacional de Técnica Aeroespacial, Spain

Coordinator: David Gómez Castro, Universidad Complutense de Madrid, Spain

Exposition of the problem: Julio Plaza del Olmo, Instituto Nacional de Técnica Aeroespacial, Spain

Introduction

Homogenization is an important tool to solve complex problems composed of multiple elements with different properties. After homogenization of a system, a problem can be simplified to a single-element problem with a single effective value that takes into account the original heterogeneity of the problem. Such solution can be applied to many different physical and chemical problems.

One such example is the case of electromagnetism. From Maxwell equations, a single equation for Electric (E) and Magnetic (B) fields can be derived (Helmoltz equations) for the propagation of electromagnetic waves of frequency ω in vacuum, at a speed of c.

However, when waves propagate through a material, the electric and magnetic fields interact with its atoms. Typically, a cubic centimeter of any material contains around 1,022 atoms inside, with their positive nuclei, and negative electrons. Solving the equation taking into account the interaction of such a high number of point charges is simply impossible, and thus a spatial and temporal homogenization is made to define effective macroscopic properties like dielectric constant (ε), magnetic permittivity (μ) and refraction index (n), as well as new variables like Displacement (D) and Magnetic Induction (H) fields which accounts for the interaction of the electromagnetic fields in the whole medium of propagation.

Nanotechnology has allowed us to artificially combine material with these macroscopic properties. The propagation of waves through these new artificial mediums composed of different materials with different properties can also be simplified with a new homogenization process to yield new values for ε, μ and n, which in some cases can lead to exotic new phenomena like negative refraction or the apparition of bands where the propagation is not possible. Such is the case of metamaterials and photonic crystals.

The possibility of design and fabrication of these new materials opens the path to the manipulation of light and its propagation that can be used in applications of security and defense.

Due to the different wavelengths that a single beam of light can transport, it becomes an important source of information of a scenario that can be exploited using sensors and detectors. Reconstruction of the spectrum of this light beam can for instance allow for the detection and identification of the presence of chemical warfare agents in the environment. For the separation of a light beam to obtain its spectrum, components that can filter and transmit extremely narrow bands are important, and can be achieved using photonic crystals.

Objectives

- Numerical simulation of problems before and after homogenization with COMSOL Multiphysics (we will give an introductory course to COMSOL).
- Study of convergence of solutions to the solution of the homogenized problem.
- Comparison with the theoretical results (which we will be briefly presented by the organizer).
- Study the computation complexity of the problem as the number of particles involves increases and compare computation times with the homogenized problem.

PROBLEM 4:

Sales forecasting model. Analysis of covariables and inclusion in the model

Proposed by: Mapal Software, Spain

Coordinators: Alba M. Franco Pereira and Elena Almaraz Luengo, Universidad Complutense de Madrid, Spain

Exposition of the problem: Iker Barriales-Valbuena, Mapal Software, Spain

The sales forecast challenge

A good and accurate prediction of demand is a key step in any business optimization process. In the restaurant sector, this accurate estimate is necessary not only to guarantee a good service to the client but also to control operating expenses.

In the restaurant industry, demand is highly patterned: sales figures represent a year periodicity, but also monthly, weekly and even hourly patterns within the day arise.

Every restaurant has its own circumstances that determine its actual figures and periodicities, but it's reasonable to think that similar concepts show similar patterns.

With this in mind, a practical approach to estimate the total sales amount for a certain day can be performed through a nearest neighbour procedure. However, there are other variables that have a great influence in the actual sales figure, like special events, singular dates or active promotions that encourage or discourage client consumption, over the baseline prospect.

The objective of this challenge is to refine the forecasting model to include other significant variables like active promotions and weather variables, evaluate whether or not they are significant and, if so, estimate the weight of their influence and modify accordingly the initial model.

Working Plan

The (non exhaustive) possible steps the participants could follow are:

- Evaluate the best model to complement the current model, which is commonly used in the restaurant sector.
- Evaluate the influence of the new variables.
- Estimate the parameters of the new model.
- Provide a final algorithm as a deliverable so that Mapal Software can reproduce the analysis and variable contrast in the future.
- Propose new approaches to sales forecasting: ARIMA, exponential…

PROBLEM 5:

Artificial cognition in neurorobotics for limb movement and manipulation

Proposed by: Instituto de Matemática Interdisciplinar, Spain

Coordinator: José Antonio Villacorta Atienza, Instituto de Matemática Interdisciplinar, Spain

Exposition of the problem: José Antonio Villacorta Atienza, Instituto de Matemática Interdisciplinar, Spain

The challenge

Nature has provided living beings with cognitive skills for interacting properly with their environment to ensure their survival. In this sense *cognition* can be defined as the set of mental abilities permitting the decision-making based on the processing of perceived and acquired information. Among these cognitive abilities the main ones, as understanding, learning and memory, are the subjects of theoretic and experimental scientific disciplines. The importance of our comprehension about cognition lays on the wide social application of this knowledge, especially in the field of robotics. In a near future the robots will be an essential part of our life, but in order to get their natural and smooth integration in our society it is desirable that their mental processes are similar to our brain mechanisms. The neurorobotics is focused on developing artificial cognition inspired by the nervous system of animals and humans to provide robots with mental abilities similar to those exhibited by living beings. This challenge will ensure that robots can interact with our world (and with us) in an efficient, versatile, and robust way, naturally facing complex tasks that demand a proper combination of movement, navigation, and manipulation.

The problem

The main context of cognition (both in biology and robotics) is the interaction with the real world.

- How does our brain understand a situation?
- Where is the difficulty?
- How can it be solved?

The objective

Cognitive interaction of robots with our world and us is far to be restricted to navigation. A central type of interaction concerns the coordinated movement of limbs for performing complex actions, in particular manipulation and locomotion, which are key abilities to ensure survival in animals and humans (run, jump, fight, etc.). The objective of this research will be to *outline the extension of the Prediction for CompAction paradigm from navigation to cognitive manipulation in dynamic situations* (as simple example, to catch a flying ball).

The research

The problem will be tackled in four steps:

- Familiarization with the mathematical modelling of perception for CompAction paradigm
- Modelling of cognitive manipulation based on PCA
- Proof of concept by simulation of some simple situations
- Conclusions and exposition

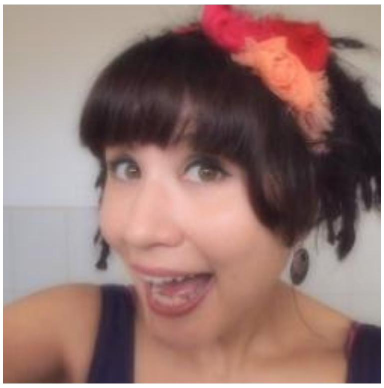
Coordinators

Problem 1: *Generating a caplet volatility surface*

Gerardo E. Oleaga Apadula
Universidad Complutense de Madrid, Spain

Problem 2: *Providing electricity in the future*

Tamsin E. Lee
University of Oxford, United Kingdom



Problem 3: *Homogenization process in nanotechnology and metamaterials*

David Gómez Castro
Universidad Complutense de Madrid, Spain

Coordinators

Problem 4: *Sales forecasting model. Analysis of covariables and inclusion in the model*

Alba M. Franco Pereira
Universidad Complutense de Madrid, Spain

Elena Almaraz Luengo
Universidad Complutense de Madrid, Spain

Problem 5: *Artificial cognition in neurorobotics for limb movement and manipulation*

José Antonio Villacorta Atienza
Instituto de Matemática Interdisciplinar, Spain

Students

Problem 1: *Generating a caplet volatility surface*

Esther Hernández Serrano	Universidad Complutense de Madrid, Spain
Sergio Ibáñez Moreno	Universidad Complutense de Madrid, Spain
Rocío Puente Ochoa	Universidad Complutense de Madrid, Spain
Mariana Villar Domínguez	Universidad Complutense de Madrid, Spain
Thomas Gaudelet	University of Oxford, United Kingdom

Problem 2: *Providing electricity in the future*

Ángela Díaz López	Universidad Complutense de Madrid, Spain
Alba García González	Universidad Complutense de Madrid, Spain
Izaskun Oregui Bravo	Universidad Complutense de Madrid, Spain
Joseph C. Foster	University of Leicester, United Kingdom
Maksim Zhuravlev	Saratov State University, Russia

Problem 3: *Homogenization process in nanotechnology and metamaterials*

Carlos Arechalde Pérez	Universidad Complutense de Madrid, Spain
Pablo Cañones Martín	Universidad Complutense de Madrid, Spain
Denis Coccolo Góngora	Universidad Complutense de Madrid, Spain
Nadia Loy	Università degli Studi di Firenze, Italy
Amarpreet Kaur	University of Leicester, United Kingdom

Problem 4: *Sales forecasting model. Analysis of covariables and inclusion in the model*

Manuel Francisco Avilés Lucas	Universidad Complutense de Madrid, Spain
Ubay Casanova Blancas	Universidad Complutense de Madrid, Spain
Imanol Gago Carro	Universidad Complutense de Madrid, Spain
Lidia Gómez-Tejedor Fernández	Universidad Complutense de Madrid, Spain
Gabriele Aiazzi	Università degli Studi di Firenze, Italy

Problem 5: *Artificial cognition in neurorobotics for limb movement and manipulation*

Jorge del Val Santos	Universidad Complutense de Madrid, Spain
Javier Espín García	Universidad Complutense de Madrid, Spain
Javier León Caballero	Universidad Complutense de Madrid, Spain
Chiara Baglioni	Università degli Studi di Firenze, Italy
Anton Selskii	Saratov State University, Russia

For non UCM participants the following costs will be covered:

Travel. Flight tickets have been bought by the organizing committee and sent to the participants by e-mail.

Accommodation. From Monday night (June 15th) to Saturday morning (June 20th) at Colegio Mayor Diego de Covarrubias (see information below).

- Single rooms for instructors
- Single rooms or shared double rooms for students

Meals. Breakfast, lunch and dinner are included in the accommodation.

Colegio Mayor Diego de Covarrubias

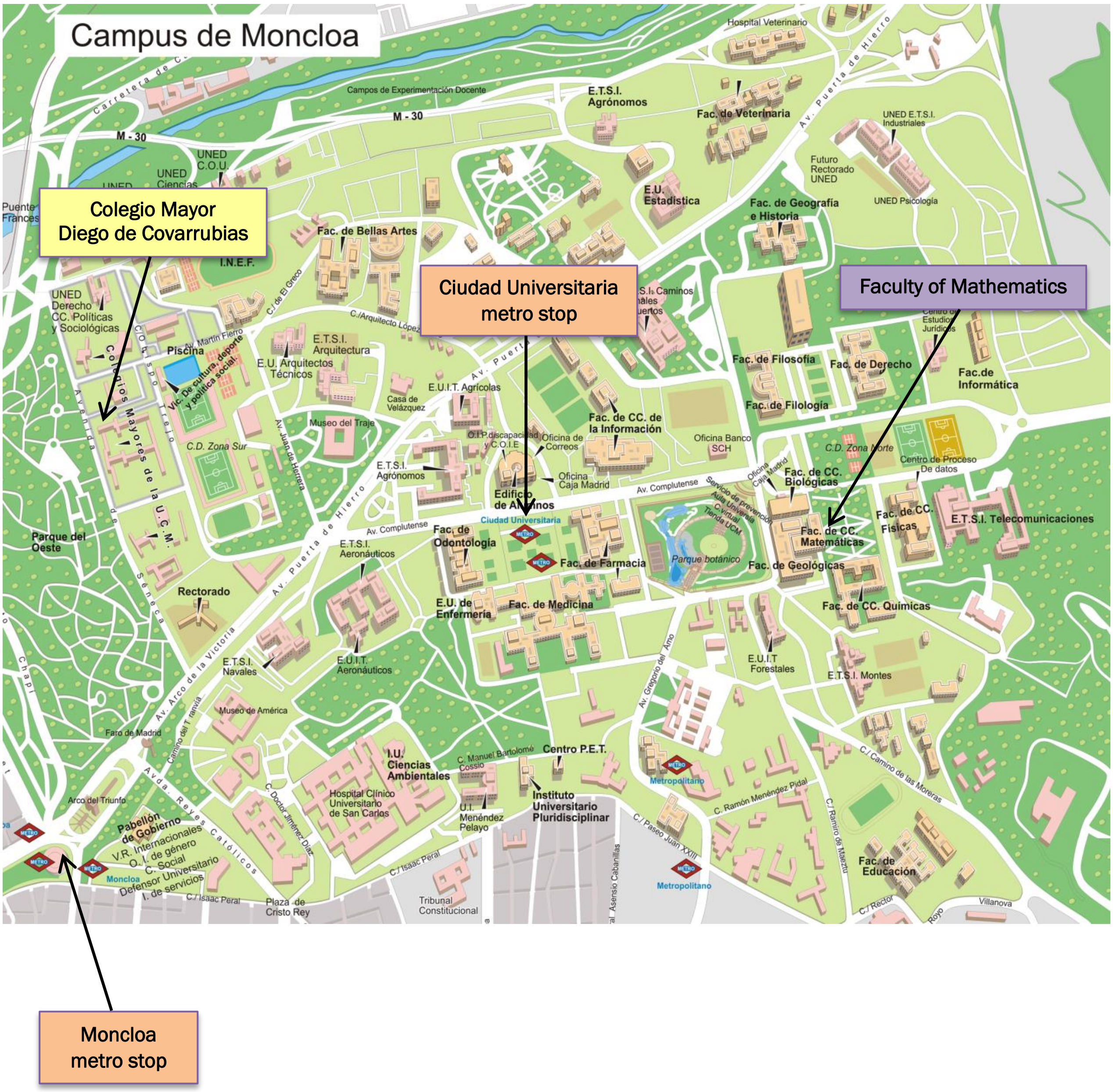
It is located in the University Campus. The address is Avenida Séneca, 10. Phone number: (+34) 91 550 46 00. The closest underground stops are Moncloa and Ciudad Universitaria (walking distance). Buses connect the residence with Moncloa (160, 161 and A) and many locations at the University campus (U).

The webpage of the residence: http://www.cmucovarrubias.es/

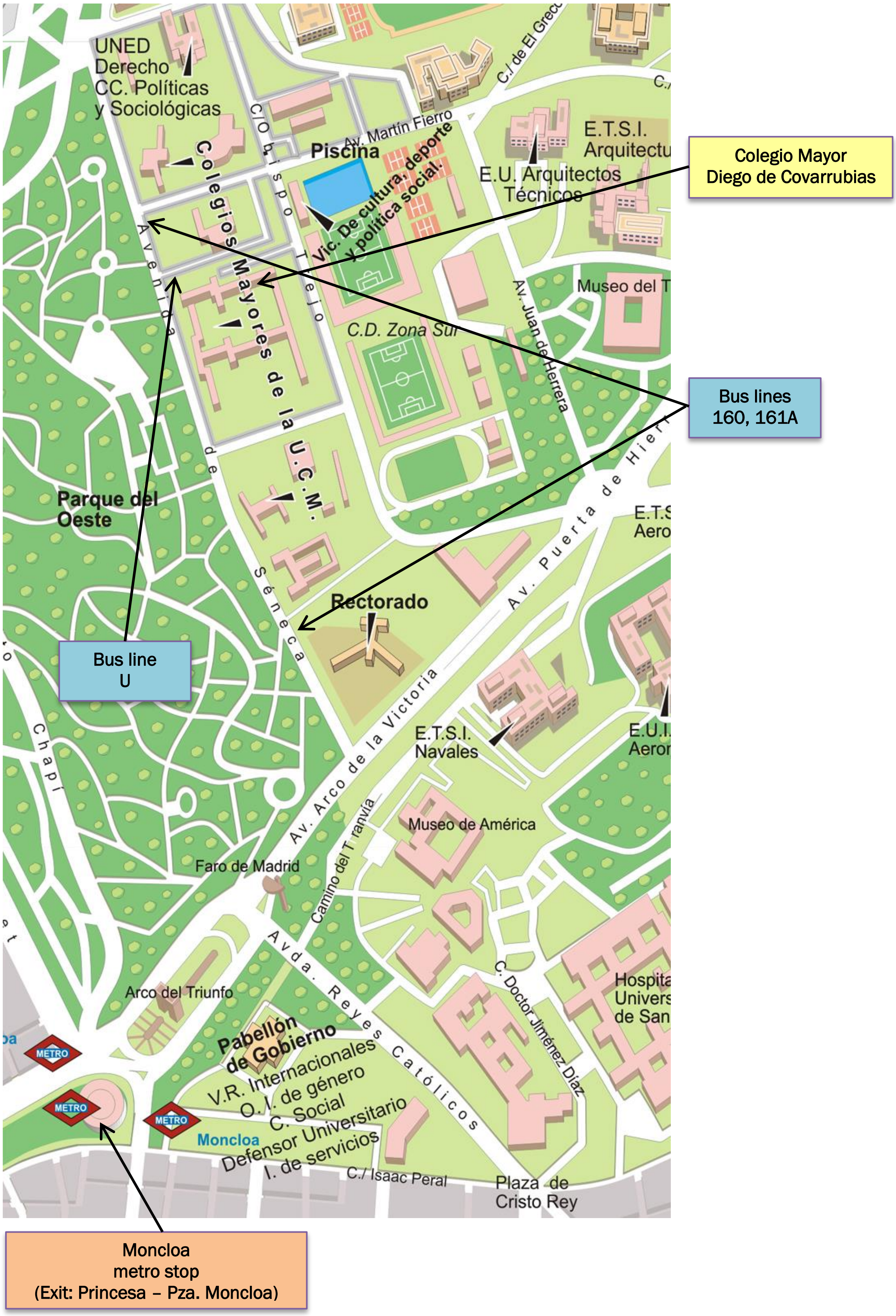
Campus Map

Faculty of Mathematics and Colegio Mayor Diego de Covarrubias at Moncloa Campus:

(Attention: this map is not north oriented)



Bus stops near Colegio Mayor Diego de Covarrubias



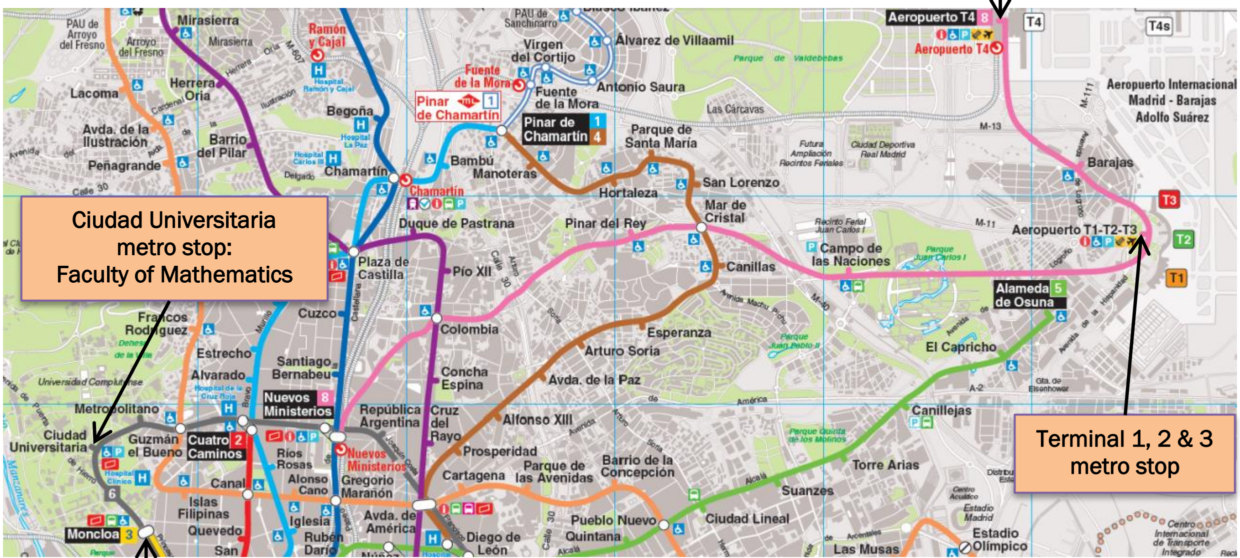
How to arrive from the airport

There are two underground (metro) stops at the airport, depending on the terminal you arrive (see metro map below). A single trip costs 5 euros from the airport to the University.

A taxi cost may vary between 40 and 60 euros from the airport to the Colegio Mayor. A taxi driver may not know how to find the place, so you better print out the map before the trip.

Directions: From the airport you can take metro line 8 bound for Nuevos Ministerios, stop at this station and then change to line 6 (counterclockwise) towards Moncloa stop

Terminal 4 metro stop



Ciudad Universitaria metro stop: Faculty of Mathematics

Terminal 1, 2 & 3 metro stop

Moncloa metro stop: Colegio Mayor Diego de Covarrubias

Moving around

Transport Information	Metro de Madrid (underground)	EMT (local buses)	Renfe Cercanías (regional trains)

Tourism

Madrid City	Madrid City and Region

Cibeles Square, Madrid

Puerta de Alcalá, Madrid