Local: Děčín, Czech Republic; Online: MS Teams
FNSPE CTU in Prague, Czech Republic

Student workshop on scientific computing 2021

August 22-24, 2021, hybrid conference (online and local)

Conference Information

The conference will be held LOCAL and ONLINE. All talks will be recorded.
The scientific colloquium of CTU organized by the departments of Software Engineering and Mathematics, FNSPE CTU in Prague is devoted to the meeting of students and young applied mathematicians dealing with numerical solution of partial differential equations, mathematical modelling, numerical simulation of problems in technology, environment, biology and computer science.

Organizers

J. Kukal, Department of Software Engineering, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague
kukal (at) dc.fjfi.cvut.cz
R. Fučík, Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague
radek.fucik (at) fjfi.cvut.cz
P. Pauš, Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague
petr.paus (at) fjfi.cvut.cz
M. Beneš, Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague
michal.benes (at) fjfi.cvut.cz
M. Kolář, Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague
miroslav.kolar (at) fjfi.cvut.cz

Organizing committee

J. Kukal, R. Fučík, M. Beneš, M. Kolář, P. Strachota, T. Oberhuber, M. Balázsová, P. Eichler

Scientific committee

J. Kukal, R. Fučík, M. Beneš, M. Kolář, P. Strachota, T. Oberhuber, M. Balázsová, P. Eichler

Additional information

URL: `http://geraldine.fjfi.cvut.cz/wsc-2021`
Venue: Local: {Děčín, Czech Republic}, Online: {MS Teams}

Acknowledgement

This workshop is supported by the Grant Agency of the Czech Technical University in Prague, grant No. SVK 40/21/F4.

List of Participants

The list of all participants in alphabetical order.

Name	University / Institute	
Monika Balázsová	FNSPE, CTU in Prague	
Michal Beneš	FNSPE, CTU in Prague	
Martin Dlask	FNSPE, CTU in Prague	Student
Pavel Eichler	FNSPE, CTU in Prague	Student
Radek Fučík	FNSPE, CTU in Prague	
Radek Galabov	FNSPE, CTU in Prague, IKEM in Prague	Student
František Gašpar	FNSPE, CTU in Prague	Student
Ján Gašper	Commenius University, Bratislava	Student
Jiří Chludil	FF, UHK	Student
Martin Jex	FNSPE, CTU in Prague	Student
Léa Keller	KTH	Student
Momomi Kimura	Meiji University	Student
Jakub Klinkovský	FNSPE, CTU in Prague	Student
Miroslav Kolář	FNSPE, CTU in Prague	
Jan Kovář	FNSPE, CTU in Prague	Student
Jaromír Kukal	FNSPE, CTU in Prague	
Dana Majerová	FNSPE, CTU in Prague	
Michal Malík	FNSPE, CTU in Prague	Student
Niels van der Meer	FNSPE, CTU in Prague	Student
Ivan Merta	FNSPE, CTU in Prague	Student
Jiri Minarcik	FNSPE, CTU in Prague	Student
Tomáš Oberhuber	FNSPE, CTU in Prague	
Yoshinori Okino	Meiji University	Student
Petr Pauš	FNSPE, CTU in Prague	
Tomáš Princ	FCE, CTU in Prague	
Jan Sembera	Technical University of Liberec	
Tomáš Smejkal	FNSPE, CTU in Prague	Student
Martina Sobotková	FCE, CTU in Prague	
Jakub Solovský	FNSPE, CTU in Prague	Student
Pavel Strachota	FNSPE, CTU in Prague	
Monika Suchomelová	FNSPE, CTU in Prague	Student
Daniel Ševčovič	Comenius University, Bratislava	

Kateřina Škardová	FNSPE, CTU in Prague	Student
Quang Van Tran	FNSPE, CTU in Prague	
Cyril Izuchukwu Udeani	Comenius University, Bratislava	Student
Shimoji Yusaku	Meiji University	Student

Scientific Programme

Conference venue:

The main building of CTU at Pohraniční street, 1288/1
or

Online: MS Teams¡strong¿¡/strong¿

Registration for local participants:

Registration for local participants takes place at the conference venue (the main building of CTU at Pohraniční street, 1288/1):
Sunday: from 14:00 to 14:50

Monday: from 8:30 to 9:00 (and during coffee breaks between the sessions)

Sunday, August 22, 2021

Mostly online sessions.

One oral presentation slot duration is 25 min = 20 min talk + 5 min for discussion.

15:00 – 15:15 *Opening ceremony by prof. Michal Beneš*

Chairman: Michal Beneš

15:15 – 15:40 **Monika Balázsová**: Vibrations of nonlinear elastic structure excited by compressible flow

15:40 – 16:05 **Radek Galabov**: Potential of computational fluid dynamics in aortic repair decision making

16:05 – 16:30 **František Gašpar**: Representation and dimension estimation of fractal sets

16:30 – 16:45 *Coffee & tea break*

Chairman: Daniel Ševčovič

16:45 – 17:10 **Pavel Strachota**: Concepts of automatic trading on crypto exchanges (poorly) supported by deep neural networks

17:10 – 17:35 **Ivan Merta**: CMA-ES with Distribution Maximizing Renyi Entropy

17:35 – 18:00 **Jaromír Kukal**: Simple difference scheme for fractional Laplacian

Monday, August 23, 2021

Mostly local sessions.

One oral presentation slot duration is 25 min = 20 min talk + 5 min for discussion.

Chairman: Miroslav Kolář

09:00 – 09:25 **Shimoji Yusaku**: Numerical Computations of snow crystal growth models by the method of fundamental solutions

09:25 – 09:50 **Martin Dlask**: Application of multidimensional fBm in mammography screening

09:50 – 10:15 **Jakub Klinkovský**: MP-PIC simulations of fluidization with kotelFoam

10:15 – 10:30 *Coffee & tea break*

Chairman: Petr Pauš

10:30 – 10:55 **Monika Suchomelová**: The Hyperbolic Mean Curvature Flow

10:55 – 11:20 **Niels van der Meer**: Mathematical Modelling in Electrocardiology

11:20 – 11:45 **Jan Kovář**: Mathematical modeling of contrast agent transport and its transfer through the vessel wall in vascular flow

11:45 – 13:30 *Lunch break*

Chairman: Radek Fučík

13:30 – 13:55 **Miroslav Kolář**: Diffusion and transport mechanism acting on moving curves

13:55 – 14:20 **Pavel Eichler**: LBM & turbulent fluid flow simulations on different lattices

14:20 – 14:45 **Michal Malík**: Two phase flow simulations using the lattice Boltzmann method

14:45 – 15:00 *Coffee & tea break*

Chairman: Jakub Solovský

15:00 – 15:25 **Kateřina Škardová**: Estimation of relaxation time T1 using the imaging sequence model

15:25 – 15:50 **Tomáš Smejkal**: Multi-phase compositional modeling in porous medium with phase equilibrium computation

15:50 – 16:15 **Martin Jex**: Optimization of the branch and bound algorithm with application for phase stability testing of multicomponent mixtures

16:15 – 16:30 *Coffee & tea break*

Chairman: Monika Balázsová

16:30 – 16:55 **Dana Majerová**: Simple Fuzzy Network for Biomedical Image Enhancement

16:55 – 17:20 **Jakub Solovský**: Mathematical model of melting of unsaturated porous media

17:20 – 17:45 **Michal Beneš**: Summary of Mathematical Model of Freezing in a Porous Medium at Micro-Scale

18:00 – 19:00 *Optional football session - bring good football shoes with you!*

Tuesday, August 24, 2021

Mostly online sessions.

One oral presentation slot duration is 25 min = 20 min talk + 5 min for discussion.

Chairman: Tomáš Oberhuber

09:00 – 09:25 **Léa Keller**: Process of freezing and thawing of porous media

09:25 – 09:50 **Jiří Chludil**: System for Historical Buildings Reconstruction

09:50 – 10:15 **Petr Pauš**: Deterministic and probabilistic approach to cross-slip in dislocation dynamics

10:15 – 10:30 *Coffee and tea break*

Chairman: Jaromír Kukal

10:30 – 10:55 **Tomáš Princ**: Pore-network Modelling of Entrapped Air in Sand Sample

10:55 – 11:20 **Cyril Izuchukwu Udeani**: Application of maximal monotone operator method for solving Hamilton-Jacobi-Bellman equation arising from optimal portfolio selection problem

11:20 – 11:45 **Quang Van Tran**: Option Pricing Based on Variance Gamma Process with Fourier Transform

11:45 – 12:00 *Closing ceremony*

List of Abstracts

The list of abstracts of all talks and posters in alphabetical order.

Vibrations of nonlinear elastic structure excited by compressible flow

Monika Balázsová
FNSPE, CTU in Prague

Sunday, August 22, 2021, 15:15 – 15:40

TBA

Summary of Mathematical Model of Freezing in a Porous Medium at Micro-Scale

Michal Beneš, Alexandr Žák, Martina Sobotková, Tissa H. Illangasekare, Lea Keller
FNSPE, CTU in Prague

Monday, August 23, 2021, 17:20 – 17:45

In the contribution, we present the model of freezing and thawing in a fully saturated porous medium. The phase transition occurs in pores of the porous medium with grains intact but participating in the heat transfer, and is accompanied by mechanical effects. The research is motivated by the development of advanced materials as well as by the climate changes inducing thawing of permanently frozen land with further environmental impact. Freezing and thawing inside the porous medium is accompanied by complex processes affected by the material between phases within the soil, bulk properties of the presented phases, and ambient physical conditions. Volumetric changes of the liquid presented in pores subjected to phase change conditions is one of crucial phenomena. Due to the generic inhomogeneity of volume occupied by the freezing porous medium, we focus on treating the phase transition at microscale. We have developed a micro-scale model describing mechanical, thermal, and phase change processes within a small sample of a porous medium. The phase change is described in the Lagrangian framework by means of the energy, Navier, and phase-field equations. A coupling of multi-physics and multiple phases is introduced. The model provides spatio-temporal dependencies of primary variables, the resulting forces exerted on grain surfaces by the change in specific volume due to phase transition, and possibly, the mean values of the key quantities useful for upscaling. The role of the model is demonstrated on several computational studies which follow recently published results.

Application of multidimensional fBm in mammography screening

Martin Dlask, Jaromir Kukal
FNSPE, CTU in Prague

Monday, August 23, 2021, 09:25 – 09:50

The talk presents a methodology of analyzing multidimensional fractional Brownian motion (fBm) and is applied for the identification of cancerous breast lumps from mammography screening images. At first, the exact method for multidimensional fBm images is presented and the accuracy of estimation

is verified on simulated data with known Hurst exponent. Unlike approximate methods for generating multidimensional fBm and its Hurst exponent estimation, this approach shows unbiased results for all processes with short memory and most of cases with long memory. We apply the technique on the mamography images while being able to prove that patients with cancerous findings have significantly higher Hurst exponent than those with a benign lump.

LBM & turbulent fluid flow simulations on different lattices

Pavel Eichler
FNSPE, CTU in Prague

Monday, August 23, 2021, 13:55 – 14:20

In this contribution, recent LBM simulations and progress in LBM will be presented. The application of LBM in the turbulent fluid flow in the fluidized bed reactor will be discussed. The LBM results are compared both with the experimental data and with the result produced with ANSYS Fluent software. Next, since all our previous turbulent fluid flow simulations have significant demands on the computational mesh, the octree structure of the computational mesh can reduce these demands. Although many numerical methods widely use this mesh refinement technique, the interpolation of discrete density functions is not straightforward in LBM. Thus, we will discuss different interpolations of density functions and their influence on the solution.

Potential of computational fluid dynamics in aortic repair decision making

Radek Galabov, Jaroslav Tintera
FNSPE, CTU in Prague, IKEM in Prague, IKEM

Sunday, August 22, 2021, 15:40 – 16:05

Atherosclerosis is a leading cause in artery stenosis and occlusion. In recent decades, open surgery has been replaced by endovascular treatment at least for the less complicated lesions. There exist various stenting and angioplastic procedures to remodel the vessel and recover blood flow. However, implanted stents further influence blood dynamics and restenoses do occur. Long-term patency depends on stent design and procedural details, but the particular mechanisms are not yet fully understood. Computational fluid dynamics offers means to investigate some of the underlying causes in occlusion disease.

Representation and dimension estimation of fractal sets

František Gašpar, Jaromír Kukal
FNSPE, CTU in Prague, FNSPE, CTU in Prague

Sunday, August 22, 2021, 16:05 – 16:30

Stochastic models of diffusion in spatial domains of noninteger dimension are widely applicable as a basis of simulations. Obtaining data having fractal properties requires the construction of fine enough discrete latices that is computationally expensive. This contribution presents a novel

way of representing self-similar fractal models using a generalized coordinate system together with statistical testing of obtained dimension estimates.

System for Historical Buildings Reconstruction

Jiří Chludil, Pauš Petr
FF, UHK, FIT, CTU in Prague

Tuesday, August 24, 2021, 09:25 – 09:50

Modern visualization technologies are becoming popular in historical sciences, e.g., digital reconstruction of historical buildings. The whole process, such as tedious work in the archive, digitizing all required materials, 3D modeling, preparation of textures, and importing a model into some visualization framework might be quite a complicated procedure for historians, especially if high standards need to be achieved. Technically demanding processes are often outsourced to external companies, which is usually expensive and time-consuming. The education process of historians nowadays contains an introduction to visualization technologies and digitization, but their knowledge is still rather limited. The process of data preparation and digitization usually goes without problems. However, 3D modeling itself followed by export to the visualization framework is far more complicated. There are usually fundamental problems in 3D models (bad topology and triangulation, etc.) and also issues with supported formats among applications. The goal of this project is to design and develop a system that helps historians to simplify and ease the process of historical buildings reconstruction by means of tools and techniques of software engineering and computer graphics. This study would like to create a full feedback system where all 3D models will be checked for quality (from a historical and computer graphics point of view) by automated and semi-automated tests. Access to all historical data as well as a backup and versioning system will be integrated into the system. Finally, the system will support exporting models to selected visualization frameworks in proper formats by means of client applications. According to the authors' experience, historians arguably are a very conservative group of scientists. Therefore, designing and testing a proper user interface in a full-fledged UX laboratory is mandatory.

Optimization of the branch and bound algorithm with application for phase stability testing of multicomponent mixtures

Martin Jex, Jiří Mikyška
FNSPE, CTU in Prague

Monday, August 23, 2021, 15:50 – 16:15

This work examines the question of VTN phase stability testing. This problem is solved by global minimization of the TPD (tangent plane distance) function. The global optimization is performed using applying the branch and bound algorithm, which is improved, in comparison to its basic variant, by using a more effective pruning of the tree arising from the algorithm. This improvement is derived from the necessary conditions of an extremum, which leads to suplementary conditions for pressure and chemical potentials. Functions describing theese conditions are not convex, therefore, in this work, we derive and apply its convex-concave decompositions.

Process of freezing and thawing of porous media

Léa Keller
KTH

Tuesday, August 24, 2021, 09:00 – 09:25

This contribution studies different experiments and mathematical models of water and soil freezing. Soil freezing has important effects in order to understand deformation of grounds, such as for instance the roads in winter. The model is based on Stefan problem which is a particular type of free boundary problem. Several experiments and models with water, sand and gas are performed and then modelled with the use of Comsol 3.3 in order to visualize the freezing evolution.

MP-PIC simulations of fluidization with kotelFoam

Jakub Klinkovský
FNSPE, CTU in Prague

Monday, August 23, 2021, 09:50 – 10:15

Multiphase particle-in-cell is an interesting method for modeling particle-fluid interactions in computational fluid dynamics, which combines the advantages of both Eulerian and Lagrangian frameworks. While the motion of particles is tracked using the Lagrangian framework, inter-particle interactions (i.e. collisions) are approximated using averaged quantities on the Eulerian grid where the fluid is simulated. According to the literature, the method is stable in dense particle flows, computationally efficient, and physically accurate, which makes it suitable for the simulation of industrial-scale chemical processes involving particle-fluid flows.
In this talk, we present the governing equations and mathematical background of the MP-PIC method, then we describe its implementation in the OpenFOAM framework and highlight our own improvements that are included in our customized "kotelFoam" solver. Finally, we present our simulations of fluidized particles in a plastic model of a bubbling fluidized bed combustor.

Diffusion and transport mechanism acting on moving curves

Miroslav Kolář
FNSPE, CTU in Prague

Monday, August 23, 2021, 13:30 – 13:55

TBA

Mathematical modeling of contrast agent transport and its transfer through the vessel wall in vascular flow

Jan Kovář
FNSPE, CTU in Prague

Monday, August 23, 2021, 11:20 – 11:45

This contribution deals with mathematical modeling of contrast agent transport and its transfer through the vessel wall in vascular flow in a two-dimensional computational domain. The problem is solved in the context of myocardial perfusion examination using a contrast agent.

The audience will be briefly introduced to a mathematical model of Newtonian incompressible fluid flow in an isothermal free flow system and a mathematical model of a contrast agent transport, in which the boundary condition modeling the transfer of the contrast agent is included. The numerical scheme of the lattice Boltzmann method used to solve the aforementioned problem will be discussed together with the results obtained by this scheme.

Simple difference scheme for fractional Laplacian

Jaromír Kukal, Michal Beneš
FNSPE, CTU in Prague, FNSPE, CTU in Prague

Sunday, August 22, 2021, 17:35 – 18:00

There are many ways how to approximate the fractional Laplacian. Preferring d-dimensional linear difference schemes and regular grids (cubic, hexagonal, dodecahedral), we obtained novel formulas with approximation order 4 - alpha. We start with principal value integral expression of the fractional Laplacian. After splitting it into singular and regular parts, we balance the approximation errors and obtained optimal radius of singularity capturing. This radius is only a function of the exponent alpha and the topology of regular grid and therefore, it can be calculated before the grid calculations. Final formula is only a linear combination of traditional Laplacian stencil and simple d-dimensional sum.

Simple Fuzzy Network for Biomedical Image Enhancement

Dana Majerová
FNSPE, CTU in Prague

Monday, August 23, 2021, 16:30 – 16:55

Digital image processing involves many techniques. One of them is image enhancement. This presentation is devoted to the processing of biomedical images using simple and advanced fuzzy filters and several kinds of min-max fuzzy networks (MMFNs). The MMFN combines selected fuzzy filters to compute a better image. The results of all fuzzy filters and the output from min-max fuzzy networks are compared on biomedical images obtained by magnetic resonance.

Two phase flow simulations using the lattice Boltzmann method

Michal Malík
FNSPE, CTU in Prague

Monday, August 23, 2021, 14:20 – 14:45

In this contribution, we will present the possibilities of using the lattice Boltzmann method, LBM for short, to simulate two phase flow. Two numerical models will be described: Shan-Chen LBM and phase-field LBM. Shan-Chen LBM can be used to simulate both miscible and immiscible flow, while phase-field LBM is only capable of the latter. We will discuss the phase separation in Shan-Chen LBM and the initial condition for phase-field LBM. Afterwards, the application of both numerical models in simulating the contact angle between fluid and solid surface will be shown.

Mathematical Modelling in Electrocardiology

Niels van der Meer, Michal Beneš
FNSPE, CTU in Prague
Monday, August 23, 2021, 10:55 – 11:20

Cardiovascular diseases account for more than thirty per cent of all deaths which makes them the most common cause of decease worldwide. It is therefore understandable that considerable effort has been exerted to treat and prevent these conditions. This talk(based on a thesis of the same name) probes for the potential contributions of mathematics and its tools developed from the theory of reaction-diffusion equations. The main area of interest is electrocardiology which studies heart rhythm disorders as well as their causes. Some of the mathematical models describing the propagation of a signal in an excitable medium are introduced. One such example is the FitzHugh–Nagumo model whose several variations were numerically analyzed and the results are presented in this talk.

CMA-ES with Distribution Maximizing Renyi Entropy

Ivan Merta, Jaromir Kukal
FNSPE, CTU in Prague
Sunday, August 22, 2021, 17:10 – 17:35

The Covariance Matrix Adaptation Evolution Strategy (CMA-ES) is a widely accepted metaheuristic optimization method. It belongs to a class of stochastic, derivative-free optimization algorithms performing well on a wide range of nonlinear, non-convex black-box functions in a continuous domain. As such, it has attracted researchers to make various modifications to the method.
In classical CMA-ES, new candidate solutions are sampled from a multivariate normal distribution. In our research, we propose a novel heavy-tailed distribution for generating the samples. The steps for generating such values are derived from a spherically symmetric distribution maximizing Renyi entropy. This approach results in a generalization CMAE-ES and classical method with a multivariate normal distribution sampling here becomes an edge case.
The performance is compared with classical CMA-ES on multiple appropriately difficult test functions.

Deterministic and probabilistic approach to cross-slip in dislocation dynamics

Petr Pauš
FNSPE, CTU in Prague
Tuesday, August 24, 2021, 09:50 – 10:15

This contribution deals with the numerical simulation of dislocation-precipitate interaction in copper crystals by means of discrete dislocation dynamics. We consider a dislocation gliding in a slip plane under an external stress field and a precipitate located in the same slip plane also generating a stress field. The precipitate stress field forces the dislocation to perform a cross-slip mechanism (i.e., change the slip plane). We present a comparison of the deterministic approach to the cross-slip mechanism with a probabilistic approach governed by a normal distribution of probability.

Pore-network Modelling of Entrapped Air in Sand Sample

Tomáš Princ, Michal Sněhota
FCE, CTU in Prague

Tuesday, August 24, 2021, 10:30 – 10:55

The relationship between entrapped air content (ω) and the corresponding hydraulic conductivity (K) was investigated experimentally for two coarse sands. Additionally the pore-network model based on OpenPNM platform was used to attempt simulation of a redistribution of the air bubbles after infiltration. Two packed samples of 5 cm height and 7.2 cm diameter were prepared for each sand. The cycles of infiltration and drainage led to entrapping of the air. The value of K was determined using Darcy's law by repetitive falling-head infiltration experiments. The entrapped air content was determined from gravimetrically after each infiltration run. The amount and distribution of air bubbles were quantified by X-ray computed tomography (CT) for selected runs. The obtained K(ω) relationship agreed well with Faybishenko's formula. CT imaging revealed that entrapped air contents and bubbles sizes were increasing with the height of the sample. It was found that the size of the air bubbles and clusters increased with each repetition of the experimental cycle. The relationship between initial and residual gas saturation was successfully fitted with a linear model. The combination of X-ray computed tomography and infiltration experiments has a potential to explore the effects of entrapped air on water flow.

Multi-phase compositional modeling in porous medium with phase equilibrium computation

Tomáš Smejkal, Jiří Mikyška
FNSPE, CTU in Prague

Monday, August 23, 2021, 15:25 – 15:50

In this contribution, we present a new numerical solution of a multi-phase miscible compressible Darcy's flow of a multi-component mixture in a porous medium. The mathematical model consists of the mass conservation equation of each component, extended Darcy's law for each phase, and an appropriate set of the initial and boundary conditions. The phase split is computed using the constant temperature-volume flash (known as VTN-specification). The transport equations are solved numerically using the mixed-hybrid finite element method and a novel iterative IMPEC scheme. We provide examples showing the performance of the numerical scheme.

Martina Sobotková
FCE, CTU in Prague

Without abstract.

Mathematical model of melting of unsaturated porous media

Jakub Solovský
FNSPE, CTU in Prague

Monday, August 23, 2021, 16:55 – 17:20

In this work, we present the simplified mathematical model of two-phase compositional flow in porous media coupled with heat conduction and phase transitions.
We implement the numerical scheme based on the mixed-hybrid finite element method for solving such problems and demonstrate the capabilities of the model on an artificial scenario inspired by the planned experiments.
Initially, the pore space of a sand-filled container is occupied by ice with entrapped gas bubbles. One wall of the container is heated, the remaining ones are insulated. The ice within a container melts and releases the trapped gas that is then transported in the already melted region and dissolves into the water.

Concepts of automatic trading on crypto exchanges (poorly) supported by deep neural networks

Pavel Strachota, Tereza Vorlová, Ondřej Šrámek
FNSPE, CTU in Prague

Sunday, August 22, 2021, 16:45 – 17:10

Let's start by a quote from the 1997 movie "The Devil's Advocate":

Kevin Lomax:
Why the **law**? Cut the sh*t, Dad! Why the lawyers? Why the law?
John Milton:
Because the **law**, my boy, puts us into everything. It's the ultimate backstage pass. It's the new priesthood, baby. Did you know there are more students in law school than lawyers walking the Earth?
Now in 2021, it's rather **machine learning** (ML) and **deep neural networks** (DNN) that put you into everything. Or perhaps it's us who try to put ML and DNN into everything. Whatever it is, this time we try to put DNN into automatic trading on cryptocurrency exchanges and see what happens. Well, so far, we're still poor scientists. We briefly touch on the role of crypto in the current world, on the possibilities of online trading on crypto exchanges, on data collection and preprocessing, and the design of DNN architectures that could possibly assist in automated trading strategies. Some preliminary experiments are also demonstrated.

The Hyperbolic Mean Curvature Flow

Monika Suchomelová
FNSPE, CTU in Prague

Monday, August 23, 2021, 10:30 – 10:55

The mean curvature flow (MCF) in plane is well studied curve dynamics with interesting properties. The hyperbolic version of this flow (HMCF) is defined by the rule that normal acceleration of the curve is equal to curvature. In addition to an initial curve, the initial velocity must be defined.
The studied equation for parametric plane curve is presented. The properties of the flow are demonstrated on computed examples of evolving closed plane curves and compared with the properties of MCF. The interesting situation happens if the initial velocity is set to be equal to initial tangent vector field.

Estimation of relaxation time T1 using the imaging sequence model

Kateřina Škardová
FNSPE, CTU in Prague
Monday, August 23, 2021, 15:00 – 15:25

In this contribution, we discuss how numerical simulations and machine learning can be combined in order to create a framework for tissue parameter estimation. The proposed approach is applied on the problem of T1 relaxation time estimation based on image series acquired by the Modified Look-Locker Inversion Recovery (MOLLI) magnetic resonance imaging sequence.
The main contribution is in combining neural network with numerical minimization. The neural network is trained using synthetic data generated by MOLLI sequence simulations based on Bloch equation. The prediction of neural network is used to initialize the numerical optimisation step. The proposed method is validated using phantoms with wide range of T1 values.

Option Pricing Based on Variance Gamma Process with Fourier Transform

Quang Van Tran
FNSPE, CTU in Prague
Tuesday, August 24, 2021, 11:20 – 11:45

The price dynamics of financial assets is traditionally modeled by a Wiener process. However, this process cannot capture the heavy tail property of assets returns. One way to solve this problem is to replace the Wiener process by the variance gamma process. However, the resulting stochastic process is more complicated and direct evaluation of option price under risk neutral measure is computationally time-consuming. As an alternative, option pricing is performed through fourier transform making use of the existence of the characteristic function of the variance gamma process. We analyze the efficency of this procedure and the effect of parameters of numerical procedure on its precision as well as its time demandingness.

Application of maximal monotone operator method for solving Hamilton-Jacobi-Bellman equation arising from optimal portfolio selection problem

Cyril Izuchukwu Udeani, Daniel Sevcovic
Comenius University, Bratislava

Tuesday, August 24, 2021, 10:55 – 11:20

In this paper, we investigate a fully nonlinear evolutionary Hamilton-Jacobi-Bellman (HJB) parabolic equation utilizing the monotone operator technique. We consider the HJB equation arising from portfolio optimization selection, where the goal is to maximize the conditional expected value of the terminal utility of the portfolio. The fully nonlinear HJB equation is transformed into a quasilinear parabolic equation using the so-called Riccati transformation method. The transformed parabolic equation can be viewed as the porous media type of equation with source term. Under some assumptions, we obtain that the diffusion function to the quasilinear parabolic equation is globally Lipschitz continuous, which is a crucial requirement for solving the Cauchy problem. We employ Banach's fixed point theorem to obtain the existence and uniqueness of a solution to the general form of the transformed parabolic equation in a suitable Sobolev space in an abstract setting. Some financial applications of the proposed result are presented in one-dimensional space.

Numerical Computations of snow crystal growth models by the method of fundamental solutions

Shimoji Yusaku, Yoshinori Okino
Meiji University, Meiji University

Monday, August 23, 2021, 09:00 – 09:25

There are several known mathematical models that describe snow crystal growth. Yokoyama-Kuroda model is well known as a representative model. In addition, Barrett et al. have proposed a model that takes into account the Gibbs-Thomson law, which was not considered in the derivation of Yokoyama-Kuroda model. Some numerical calculations have already been done for these problems. However, to the best of our knowledge, there are no numerical calculations using the MFS. In this talk, we will report the results of numerical calculations using MFS for these models.