Thesis topics for Computer Science MSc students (last update: 22.09.2022)

Name of the supervisor	Title of the thesis	Short description of the work	To which students does the supervisor recommend the topic?	E-mail
Csaba Gáspár	The Method of Fundamental Solutions for solving Laplace equation.	The method is a special meshless method which requires neither domain nor boundary mesh structure. In the thesis, the matematical steps of the method should be outlined through the example of the 2D Laplace equation. The method should be illustrated through several test examples, reflecting to the exactness as well as the main numerical properties of the method.	The topic is recommended to students who are interested in mathematical modelling of physical processes as well as in numerical solution of partial differential equations.	gasparcs@math.sze.hu
Csaba Gáspár	The Method of Fundamental Solutions for solving nonhomogeneous problems.	This method provides the solution of the original nonhomogeneous partial differential equation (e.g. the simplest Poisson problem) as a sum of homogeneous solution and a particular solution. The homogeneous solution can be calculated by the classical Method of Fundamental Solutions, while a particular solution can be constructed by some scattered data interpolation technique. In the thesis, the matematical background should be outlined in details. The method should be illustrated through several test examples, which demonstrate the numerical abilities and the computational properties of the method.	The topic is recommended to students who are interested in mathematical modelling of physical processes as well as in numerical solution of partial differential equations.	gasparcs@math.sze.hu
Gabor Takacs	AI based street garbage detector	Littering is not only an aesthetic but also an environmental issue. The goal of the thesis project is to design and implement an AI based system that is able to recognize if an image shows street garbage or not. The long-term goal would be to build a garbage collector robot, but the current thesis project only aims at the garbage recognition part.

For training a garbage recognition model, a set of labeled images is necessary (so that label 0 means no garbage, and label 1 means that there is garbage somewhere in the image). A data set of 811 labeled images is available for the project as a starting point. Doubling the size of this data set is part of the task. | For those who completed the Neural Networks elective course with a grade of at least 4 (good). | gtakacs@math.sze.hu |
Tamás Hajba	Comparing solution methods of the clustered traveling salesman problem	The clustered traveling salesman problem is a generalization of the traveling salesman problem where the nodes are divided into clusters and the cities of each cluster must be visited contiguously. In the thesis different mixed integer programming models of the problem should be introduced and furthermore a heuristic choosen from the literature should be implemented. The efficiency of the mathematical models and the heuristic should be compared through text examples.	The topic is recommended to students who completed Linear Optimization.	hajbat@sze.hu
Mihály Markót	Optimization algorithms for bin and sphere packings	Finding the optimal or near-optimal arrangements of various three-dimensional objects is an essential ingredient of logistics, with countless applications in storage and transportation. Despite its practical importance, currently only the packing of boxes is widely studied (bin packing), but very little is known about the arrangements of other shapes and about packing objects of mixed shapes. The subject of the thesis work is to explore, implement, and compare heuristic algorithms for packing spheres of different sizes, and for packing mixed sets of boxes and spheres into box-shaped containers.	The topic is recommended to students with interest in Nonlinear Optimization.	mihaly.markot@univie.ac.at
László Környei	GPU programming with OpenMP	OpenMP 4.5 introduced support for GPUs. However, question remains how efficient it is to use this API, and what kind of performances can be achived. The work consist of taking some basic or optimized CPU implementations of a predefined problem, parallelizing it with OpenMP and CUDA, measuring speedup and implementation time.	The topic is recommended to students who completed HPC technologies and are interested in GPU programming	laszlo.kornyei@math.sze.hu
Lotfi Abdelhakim	DEVELOPMENT AND APPLICATION OF REDUCED-ORDER MODELING FOR THERMAL SIMULATION	Many physical phenomena such as heat transfer, fluid flow and mechanical deformation are modeled by partial differential equations (PDE). Traditional discretization techniques for PDEs, such as Finite Elements (FE), Finite Volumes (FV), finite difference (FD) methods, lead to very high-dimensional systems. Numerical algorithms used to compute the approximated solutions may lead to very high computational costs and storage requirements. Reduced-order modeling techniques (ROM) aim to replace the high-dimensional problems with low-dimensional models, which can significantly decrease computational demands. This work focuses on constructing reduced order model using proper orthogonal decomposition (POD), the application of developed method to thermal problems and the study of the performance of the proposed approach in terms of accuracy and speed-up with respect to full order model. All simulations in this work must be developed through the Python interface of the finite element platform FEniCS.	This work is recommended to students who have passed the following courses: Numerical methods for differential equations and Model order reduction. A preliminary preparation for this work will be treated in the courses Project work 1 and Project work 2.	lotfi@math.sze.hu
Fülep Dávid	Image analysis applied in agriculture	Image analysis algorithms has many potential applications for controlling agricultural processes. Algorithms can estimate yield of an agricultural product, or the incidence rate of a disease or weed in a given area. Inputs of these inspections are images shot by drones or satellites in many different wave lengths.	This work is recommended to students who have got experience in AI and python programming. A preliminary preparation for this work will be treated in the courses Project work 1 and Project work 2.	fulep@math.sze.hu
Fülep Dávid	Analysing human text	Typical areas of data processing typically involve exact numbers or well-defined text values. This work focuses on the cases what data analysis should be done on human text. Sentences formulated in human language must be interpreted by a machine to be suitable for processing with traditional data analysis techniques.	This work is recommended to students who have got experience in AI and python programming. A preliminary preparation for this work will be treated in the courses Project work 1 and Project work 2.	fulep@math.sze.hu
Zoltán Horváth	Development of a simulation digital twin for compressible fluids	The student shall develop a code for the simulation of compressible fluids (e.g. compressible Euler equations). The simulation is requested to be paralelly efficient. A model reduction method shall be applied (e.g. POD-DEIM), sensor inputs can be either one of the real sensors of the university or sensor data shall be simulated. Investigation of different machine learning based methods for the classical interpolatory tasks is an optional task of the thesis work. The developed code shall be applied to a problem of interest in industrial environmental or other application.	This topic is recommended to students familiar with the digital twin approach, numerical linear algebra (SVD algorithms and codes), numerical methods for differential equations at advanced level. A preliminary preparation for this work will be treated in the courses Project work 1 and Project work 2.

Several students may work in collaboration for one actual digital twin implementation with clearly separated tasks. | horvathz@math.sze.hu |