

“GHEORGHE ASACHI” TECHNICAL UNIVERSITY OF IAȘI, ROMANIA
Faculty of Automatic Control and Computer Engineering
Department of Computer Science and Engineering
Competition for the position of Associate Professor, position no. 14
Courses for the position: Fundamentals of Machine Learning, Deep Learning,
Graphics Processing Systems

Thematic area

related to the the lecture from the thematic area
for the competition for the academic position of associate professor no. 14
from the posts of the staff of the Department of Computer Engineering
for the academic year 2024-2025

Fundamentals of Machine Learning

- **Supervised Learning:** principles, definitions, key concepts; fundamental methods: K-Nearest Neighbors, Naive Bayes, decision trees, linear/polynomial regression etc.
- **Unsupervised Learning:** principles, definitions; clustering methods: K-Means, hierarchical clustering, expectation-maximization, DBSCAN.
- **Feature Engineering:** definitions; standardization, normalization, feature encoding; polynomial features, interaction terms; feature selection, feature extraction.
- **Ensemble Methods:** introduction to ensembles; types of ensembles: bagging, boosting, stacking; Random Forest, AdaBoost.
- **Neural Networks:** fully-connected neural networks: principles, structure; forward propagation, backpropagation; activation functions; optimization methods for training; convolutional and recurrent network basics; frequently-used deep neural network architectures: U-Net, VGGNet, ResNet etc.
- **Encoder-decoder Models:** general encoder-decoder layout; architectures based on recurrent layers; applications for text processing.
- **Overfitting and Regularization:** definitions; causes; negative effects on model training and use; regularization techniques (L1, L2, dropout, early stopping etc.).
- **Hyperparameter Optimization:** motivation; popular methods: grid search, random search, hyperband.
- **Evaluation of Machine Learning Models:** evaluation metrics: accuracy, precision, recall, F1 score; cross-validation; bias-variance tradeoff.

Deep Learning

- **Deep Learning Basics:** definitions, key concepts; classic neural networks vs deep neural networks; overview of popular deep learning frameworks: Pytorch, TensorFlow+Keras
- **Tensor-based Computing:** definitions, tensor properties; common tensor operations: addition, multiplication, broadcasting, reshaping, slicing; tensor differentiation.

- **Static and Dynamic Models:** online vs offline training; static and dynamic model generation; static and dynamic computational graphs – advantages and disadvantages.
- **Data Set Management:** data sets of different types and data loaders; data preprocessing techniques; data splitting techniques; handling unbalanced data sets; data augmentation methods; dividing data into batches.
- **Convolutional and Recurrent Layers:** outline of convolutional neural networks; advantages of convolutional layers in neural network architectures; feature extraction in convolutional layers; propagation of data through convolutional layers; recurrent layers – advantages for processing sequences; propagation of data through recurrent layers; improvements on traditional recurrency: LSTM, GRU networks.
- **Time Series Models:** definitions of time series data; challenges of time series data: seasonality, non-stationarity, irregularity; autoregressive and moving average models; temporal convolutional neural networks; deep neural networks for time-series data.
- **Seq2Seq Attention Models:** architecture of a traditional Seq2Seq (Sequence-to-sequence) model; attention mechanisms in Seq2Seq models; applications for machine translation.

Graphics Processing Systems

- **2D Graphics Transformations:** geometric transformations: translation, rotation, scaling, mirroring.
- **Viewing Transformations:** 2D coordinate system transformations; window-viewport transformation.
- **OpenGL Graphics Pipeline:** representation of 2D and 3D scenes in OpenGL; programmable OpenGL pipeline; shader programs.
- **Graphics Processor Programming:** GLSL language; GLSL-specific variables; vertex and fragment shaders; vertex buffer objects (VBO) and vertex array objects (VAO).
- **Composing Geometric Transformations:** transformation matrix stack; methods for managing transformations in a graphics scene.
- **Local Illumination Models:** the Phong model: ambient, diffuse, and specular lighting; per-vertex and per-pixel lighting.
- **Texturing:** defining textures; texture coordinates; texture filtering; compositing semi-transparent textures.
- **Normal Mapping:** methods for modifying normal directions; normal mapping using textures and/or random variables.

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