NEVRONSKE MREŽE

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	NEVRONSKE MREŽE
Course title:	NEURAL NETWORKS
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	**Študijska smer**	**Letnik**	**Semestri**	**Izbirnost**
Strojništvo, tretja stopnja, doktorski (od študijskega leta 2022/2023 dalje)	Ni členitve (študijski program)		Celoletni	izbirni

Univerzitetna koda predmeta/University course code:	0033417
Koda učne enote na članici/UL Member course code:	7009

Predavanja /Lectures	**Seminar /Seminar**	**Vaje /Tutorials**	**Klinične vaje /Clinical tutorials**	**Druge oblike študija /Other forms of study**	**Samostojno delo /Individual student work**	**ECTS**
90					160	10

Nosilec predmeta/Lecturer:	Edvard Govekar, Primož Potočnik

Izvajalci predavanj:	Edvard Govekar, Primož Potočnik
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course type:	Izbirni predmet /Elective course

Jeziki/Languages:	Predavanja/Lectures:	Angleščina, Slovenščina
	Vaje/Tutorial:	Angleščina, Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Veljajo splošni pogoji za doktorski študij.	General prerequisites for the third level studies.

Vsebina:	**Content (Syllabus outline):**
(i) Splošna predstavitev Kaj je nevronska mreža, biološke nevronske mreže, umetne nevronske mreže, prednosti nevronskih mrež, kratka zgodovina nevronskih mrež, uporaba nevronskih mrež (ii) Model nevrona, arhitekture mrež in učenje Model nevrona, aktivacijske funkcije, arhitekture mrež, učni algoritmi, paradigme učenja, učne naloge, predstavitev znanja, nevronske mreže napram statističnim metodam (iii) Perceptroni in linearni filtri Perceptron nevron, perceptronsko učno pravilo, ADALINE, LMS učno pravilo, adaptivni filtri, XOR problem (iv) Vzvratno učenje (backpropagation) Večnivojske mreže, algoritem vzvratnega učenja, uporaba vzvratnega učenja, napredni algoritmi, zmogljivosti večnivojskih perceptronov (v) Dinamične mreže Zgodovinske dinamične mreže, nevronska mreža s fokusirano časovno zakasnitvijo, nevronska mreža s porazdeljeno časovno zakasnitvijo, NARX mreža, mreža s povratnimi plastmi, zmogljivosti dinamičnih nevronskih mrež, učni algoritmi, identifikacija sistemov, modelno	(i) General Introduction What is a neural network?, Biological neural networks, Human nervous system, Artificial neural networks, Benefits of neural networks, Brief history of neural networks, Applications of neural networks (ii) Neuron Model, Network Architectures and Learning Neuron model, Activation functions, Network architectures, Learning algorithms, Learning paradigms, Learning tasks, Knowledge representation, Neural networks vs. statistical methods (iii) Perceptrons and Linear Filters Perceptron neuron, Perceptron learning rule, Adaline, LMS learning rule, Adaptive filtering, XOR problem (iv) Backpropagation Multilayer feedforward networks, Backpropagation algorithm, Working with backpropagation, Advanced algorithms, Performance of multilayer perceptrons (v) Dynamic Networks Historical dynamic networks, Focused time-delay neural network, Distributed time-delay neural network, NARX network, Layer recurrent network, Computational power of dynamic

referenčno adaptivno vodenje (vi) Mreže radialnih baznih funkcij (RBFN) struktura RBFN mrež, natančna interpolacija, radialne bazne funkcije, mreža radialnih baznih funkcij, RBFN učenje, RBFN za razpoznavanje vzorcev, primerjava z večnivojskim perceptronom, verjetnostne nevronske mreže (PNN), posplošene regresijske mreže (GRNN) (vii) Samo-organizirajoče se mreže Samo-organizacija, samo-organizirajoče se preslikave (SOM), SOM algoritem, lastnosti SOM mreže, učenje z vektorsko kvantizacijo (LVQ) (viii) Praktični napotki Priprava podatkov, izbira vhodov, kodiranje podatkov, metoda glavnih osi (PCA), invariance in predhodno znanje, posploševanje, splošna načela za izgradnjo nevronskih mrež (ix) Napredne vsebine Optimalna zgradba mreže, evolucija nevronskih mrež, mreže podpornih vektorjev (SVM), cammittee stroji, naključnostni stroji, mreže glavnih osi	networks, Learning algorithms, System identification, Model reference adaptive control (vi) Radial Basis Function Networks RBFN structure, Exact interpolation, Radial basis functions, Radial basis function networks, RBFN training, RBFN for pattern recognition, Comparison with multilayer perceptron, Probabilistic networks, Generalized regression networks (vii) Self-organizing maps Self-organization, Self-organizing maps, SOM algorithm, Properties of the feature map, Learning vector quantization (viii) Practical Considerations Preparing data, Selection of inputs, Data encoding, Principal component analysis, Invariances and prior knowledge, Generalization, General guidelines

Temeljna literatura in viri/Readings:

[1] S. Haykin: Neural Networks: A Comprehensive Foundation, 2/E, Prentice Hall, 1999.

[2] C.M. Bishop: Neural Networks for Pattern Recognition, Oxford University Press, 1995.

[3] I. Grabec, W. Sachse: Synergetics of measurement, prediction and control, Berlin; Heidelberg; New York: Springer, 1997.

[4] W. Sarle: Neural FAQ, ftp://ftp.sas.com/pub/neural/FAQ.html, 2002.

[5] MATLAB Neural Networks Toolbox (User's Guide), http://www.mathworks.com/access/helpdesk/help/toolbox/nnet/

Cilji in kompetence:	**Objectives and competences:**
Cilji: (i) predstaviti principe in metode nevronskih mrež,	**Goals:** The objectives of the course are: (i) to introduce the principles and

(ii) predstaviti poglavitne modele nevronskih mrež, (iii) prikazati postopek uporabe nevronskih mrež v praksi. **Kompetence:** Študent bo: (i) pridobil razumevanje koncepta neparametričnega modeliranja z nevronskimi mrežami, (ii) znal razložiti poglavitne arhitekture nevronskih mrež (večnivojski perceptron, dinamične nevronske mreže, mreže radialnih baznih funkcij, samo-organizirajoče se mreže), (iii) razvil sposobnost izgradnje nevronskih mrež za reševanje realnih problemov, (iv) zmožen zasnovati ustrezno arhitekturo nevronske mreže, doseči dobre učne in posplošitvene rezultate, ter izdelati rešitev z nevronskimi mrežami.	methods of neural networks, (ii) to present the principal neural network models, (iii) to demonstrate the process of applying neural networks in practice. **Competences:** The student will: (i) understand the concept of nonparametric modelling by neural networks, (ii) explain the most common NN architectures (multilayer perceptrons, dynamic networks, radial basis function networks, self-organized networks), (iii) develop the ability to construct neural networks for solving real-world problems, (iv) be able to design proper NN architecture, achieve good training and generalization performance, and finally, implement a neural network solution.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študent bo: (i) pridobil razumevanje koncepta neparametričnega modeliranja z nevronskimi mrežami, (ii) znal razložiti poglavitne arhitekture nevronskih mrež (večnivojski perceptron, dinamične nevronske mreže, mreže radialnih baznih funkcij, samo-organizirajoče se mreže), (iii) razvil sposobnost izgradnje nevronskih mrež za reševanje realnih problemov, (iv) zmožen zasnovati ustrezno arhitekturo nevronske mreže, doseči dobre učne in posplošitvene rezultate, ter izdelati rešitev z nevronskimi mrežami.	The student will: (i) understand the concept of nonparametric modelling by neural networks, (ii) explain the most common NN architectures (multilayer perceptrons, dynamic networks, radial basis function networks, self-organized networks), (iii) develop the ability to construct neural networks for solving real-world problems, (iv) be able to design proper NN architecture, achieve good training and generalization performance, and finally, implement a neural network solution.

Metode poučevanja in učenja:	**Learning and teaching methods:**

Predavanja, laboratorijske vaje, seminarsko delo, e-izobraževanje, konzultacije. Seminarsko delo v čim večji meri navezujoče se na področje doktorskega raziskovanja. Študij z uporabo priporočene literature.	Lectures, laboratory practice & seminar work, e-education, consulting. The seminar work is related, as much as possible, to the student's doctoral research field. Study on a recommended literature basis.

Načini ocenjevanja:	**Delež/ Weight**	**Assessment:**
Ocena je sestavljena iz seminarja (100%). Ocena seminarja je sestavljena iz pisnega dela (40%) in predstavitve ter ustnega zagovora (60%).		The grade is determined from the seminar (100%). The seminar grade consists of the written part (40%), presentation and oral defence (60%).

Reference nosilca/Lecturer's references:

prof. dr. Edvard GOVEKAR

BERLEC, Tomaž, POTOČNIK, Primož, GOVEKAR, Edvard, STARBEK, Marko. A method of production fine layout planning based on self-organising neural network clustering. International Journal of Production Research, ISSN 0020-7543, 2014, vol. 52, iss. 24, str. 7209-7222.

16. FLORJANIČ, Blaž, GOVEKAR, Edvard, KUZMAN, Karl. Neural network-based model for supporting the expert driven project estimation process in mold manufacturing. Strojniški vestnik, ISSN 0039-2480, Jan. 2013, vol. 59, no. 1, str. 3-13.

BORŠTNIK, A., GOVEKAR, E., GRABEC, I. Modeling the field of laser welding melt pool by RBFNN. Dyn. contin. discrete impuls. syst., 2007, vol. 14, suppl. 1, pp. 227-231.

doc. dr. Primož Potočnik

POTOČNIK, Primož, MISSON, Martin, ŠTURM, Roman, GOVEKAR, Edvard, KEK, Tomaž. Deep feature extraction based on ae signals for the characterization of loaded carbon fiber epoxy and glass fiber epoxy composites. Applied sciences. Feb. 2022, vol. 12, iss. 4, str. 1-13, ilustr. ISSN 2076-3417. https://www.mdpi.com/2076-3417/12/4/1867, DOI: 10.3390/app12041867. [COBISS.SI-ID 97798403]

POTOČNIK, Primož, OLMOS LOPEZ-ROSO, Borja, VODOPIVEC, Lučka, SUSIČ, Egon, GOVEKAR, Edvard. Condition classification of heating systems valves based on acoustic features and machine learning. Applied acoustics. [Print ed.]. Mar. 2021, vol. 174, str. 1-9, ilustr. ISSN 0003-682X. https://www.sciencedirect.com/science/article/pii/S0003682X20308409?via%3Dihub, DOI: 10.1016/j.apacoust.2020.107736. [COBISS.SI-ID 35370243]

POTOČNIK, Primož, ŠKERL, Primož, GOVEKAR, Edvard. Machine-learning-based multi-step heat demand forecasting in a district heating system. Energy and buildings. [Print ed.]. Feb. 2021, vol. 233, str. 1-14, ilustr. ISSN 0378-7788. https://www.sciencedirect.com/science/article/pii/S0378778820334599?via

%3Dihub, DOI: 10.1016/j.enbuild.2020.110673. [COBISS.SI-ID 45195779]

HRIBAR, Rok, POTOČNIK, Primož, ŠILC, Jurij, PAPA, Gregor. A comparison of models for forecasting the residential natural gas demand of an urban area. Energy. Jan. 2019, vol. 167, str. 511-522, ilustr. ISSN 0360-5442. https://www.sciencedirect.com/science/article/pii/S0360544218321728?via %3Dihub, DOI: 10.1016/j.energy.2018.10.175. [COBISS.SI-ID 31841575]

POTOČNIK, Primož, GOVEKAR, Edvard. Semi-supervised vibration-based classification and condition monitoring of compressors. Mechanical systems and signal processing. Sep. 2017, vol. 93, str. 51-65, ilustr. ISSN 0888-3270. http://www.sciencedirect.com/science/article/pii/S088832701730047X, DOI: 10.1016/j.ymssp.2017.01.048. [COBISS.SI-ID 15296539]

POTOČNIK, Primož, SOLDO, Božidar, ŠIMUNOVIĆ, Goran, ŠARIĆ, Tomislav, JEROMEN, Andrej, GOVEKAR, Edvard. Comparison of static and adaptive models for short-term residential natural gas forecasting in Croatia. Applied energy. Sep. 2014, vol. 129, str. 94-103, ilustr. ISSN 0306-2619. [COBISS.SI-ID 13478939]

BERLEC, Tomaž, POTOČNIK, Primož, GOVEKAR, Edvard, STARBEK, Marko. A method of production fine layout planning based on self-organising neural network clustering. International Journal of Production Research. 2014, vol. 52, iss. 24, str. 7209-7222, ilustr. ISSN 0020-7543. DOI: 10.1080/00207543.2014.910619. [COBISS.SI-ID 13421083]

SMREKAR, Jure, POTOČNIK, Primož, SENEGAČNIK, Andrej. Multi-step-ahead prediction of NOx emissions for a coal-based boiler. Applied energy. Jun. 2013, vol. 106, str. 89-99, ilustr. ISSN 0306-2619. DOI: 10.1016/j.apenergy.2012.10.056. [COBISS.SI-ID 12669211]