UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Senzorska omrežja za nadzor stanja industrijske opreme
Course title:	Sensor Networks for Condition Monitoring of Industrial Assets

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Senzorske tehnologije, 3. stopnja	/	1	1
Sensor Technologies, 3rd cycle	/	1	1

Vrsta predmeta / Course type | Izbirni / Elective

Univerzitetna koda predmeta / University course code: | ST3-549

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
15	15			15	105	5

*Navedena porazdelitev ur velja, če je vpisanih vsaj 15 študentov. Drugače se obseg izvedbe kontaktnih ur sorazmerno zmanjša in prenese v samostojno delo. / This distribution of hours is valid if at least 15 students are enrolled. Otherwise the contact hours are linearly reduced and transfered to individual work.

Nosilec predmeta / Lecturer: | Prof. dr. Đani Juričić

Jeziki / Languages:	**Predavanja / Lectures:**	Slovenski ali angleški / Slovene or English
	Vaje / Tutorial:	Slovenski ali angleški / Slovene or English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

Prerequisits:

Zaključen študij druge stopnje ustrezne (naravoslovne ali tehniške) smeri ali zaključen študij drugih smeri z dokazanim poznavanjem osnov področja predmeta (pisna dokazila, pogovor).	Completed second cycle studies in natural sciences or engineering or completed second cycle studies in other fields with proven knowledge of fundamentals in the field of this course (certificates, interview).

Vsebina:

- Pomen sistemov sprotnega nadzora v procesu vzdrževanja industrijske opreme.
- Taksonomija procesa diagnostike stanja opreme in prognostike življenjske dobe.
- Gradniki industrijskih senzorskih omrežij, senzorji in mikrosenzorji, pametna vozlišča, sistemi na čipu, prevajalni vmesniki.
- Sinteza značilk, Fourierjeva in valčna transformacija, spektri višjega reda, spektralni kurtosis, entropijski indeksi.
- Postopki na podlagi analitičnega modela procesa: strukturirani residuali, (nelinearni) Kalmanov filter.
- Detekcija spremembe trendov, zlivanje značilk.

Content (Syllabus outline):

- The role of condition monitoring in the maintenance of industrial assets.
- The taxonomy of asset condition monitoring and prognostics of the remaining useful life.
- Components of the industrial sensor networks, sensors and micro-sensors, smart nodes, systems on chip, gateways and protocol converters.
- Feature extraction, Fourier and wavelet transforms, high-order spectra, spectral kurtosis, entropy indices.
- Model based approaches: residuals, (non-linear) Kalman filter.
- Trend change detection, feature fusion,

• Prognostika: statistični pristopi na podlagi signifikantnega nabora vzorcev. • Zbiranje, shranjevanje in prikaz podatkov v senzorskem omrežju, integracija z drugimi informacijskimi sistemi v podjetju, MIMOSA OSA EAI standard. • Izvedeni primeri iz industrijske prakse. • Individualna obravnava realnega primera iz študentovega raziskovalnega dela.	• Prognostics: statistical approaches based on historical records. • Data acqusition, storage and display in sensor networks, integration with existing information systems, MIMOSA OSA EAI standard. • Industrial case studies. • Individual study of a real case from student's research work.

Temeljni literatura in viri / Readings:

Knjige / Books:
• R. B. Randall. Vibration-based Condition Monitoring. Wiley, 2011.
• S. Mallat. A Wavelet Tour of Signal Processing. Academic Press, Burlington, MA, 3rd edition, 2008.

Revije / Periodicals:
• Mechanical Systems and Signal Processing.
• Sensors.
• Journal of Intelligent Manufacturing.

Cilji in kompetence: / **Objectives and competences:**

Cilji: • razumevanje taksonomije senzorskih omrežij v kontekstu nadzora stanja opreme, • spoznanje osnovnih konceptov nadzora stanja opreme, • obvladovanje osnovnih postopkov obdelave podatkov, ki se zajemajo v senzorskih omrežjih, • spoznavanje študentov s praktičnimi problemi. Kompetence: • sposobnost analize zahtev za sisteme nadzora stanja opreme, • sposobnost konfiguriranja senzorskih omrežij za diagnostiko in prognostiko sistemov, • sposobnost načrtovanja postopkov za zlivanje senzorskih signalov, • sposobnost uporabe MIMOSA podatkovne baze.	Course objectives: • understanding the taxonomy of sensor networks in the area of condition monitoring, • becoming familiar with basic concepts of condition monitoring, • getting acquainted with basic signal processing algorithms in sensor networks, • making students familiar with practical problems. Competences: • ability to perform requirements analysis for condition monitoring systems, • ability to configure a sensor network for system diagnostics and prognostics, • ability to design algorithms for sensor fusion, • ability to make use of MIMOSA database.

Predvideni študijski rezultati: / **Intended learning outcomes:**

• Osnovne veščine potrebne za konfiguriranje senzorskega omrežja za sprotni nadzor opreme. • Pregled nad temeljnimi tehnikami nadzora stanja za industrijsko uporabo. • Razumevanje in osnovne veščine za integracijo sistemov za sprotni nadzor opreme v industrijskih proizvodnih sistemih.	• Basic skills in configuring sensor networks for on-line condition monitoring. • State-of-the art overview of basic condition monitoring techniques for industrial use. • Awareness and basic skills for integration of on-line condition monitoring systems in production information systems.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Interaktivno delo s študentom, dopolnjeno s simulacijskimi in eksperimentalnimi primeri. Predstavitev izvedbenih primerov. Samostojno seminarsko delo za posebno izbrane probleme.	Interactive work with students supported by simulated and experimental examples. Presentation of case studies. Seminar work on a selected topic.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Seminarska naloga s predstavitvijo in zagovorom rešitve izbranega primera iz študentovega raziskovalnega dela.	60 %	Seminar work with presentation and defence of the solution for the selected problem from student's research work.
Ustni izpit.	40 %	Oral exam.

Reference nosilca / Lecturer's references:

- S. Strmčnik, Đ. Juričić (Eds.) Case Studies in Control: Putting Theory to Work. Springer, 2013.
- Đ. Juričić, P. Boškoski, M. Gašperin, "Diagnostics and prognostics of rotational machines in non-stationary conditions : how much do details matter?", CM 2012/MFPT 2012, The 9th International Conference on Condition Monitoring and Machinery Failure Prevention Technologies, 12-14 June 2012, London. (Invited semi-plenary)
- P. Boškoski, Đ. Juričić. Fault detection of mechanical drives under variable operating conditions based on wavelet packet Rényi entropy signatures. Mech. Syst. Signal Process.. 2012, vol. 31, pp. 369-381.