

AVTOMATIZACIJA PROIZVODNJE

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Avtomatizacija proizvodnje
Course title:	MANUFACTURING AUTOMATION
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - Razvojno raziskovalni program, druga stopnja, magistrski	Mehatronika in laserska tehnika (smer)	2. letnik	1. semester	obvezni

Univerzitetna koda predmeta/University course code:	0566823
Koda učne enote na članici/UL Member course code:	6063-M

Predavanja /Lectures	Seminar /Seminar	Vaje /Tutorials	Klinične vaje /Clinical tutorials	Druge oblike študija /Other forms of study	Samostojno delo /Individual student work	ECTS
30		30			65	5

Nosilec predmeta/Lecturer:	Drago Bračun
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Izvajalci predavanj:	
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course	Obvezni strokovni predmet na smeri Mehatronika in
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type:

laserska tehnika, ki je izbirni strokovni predmet na ostalih smereh./Compulsory specialised course in the study of Mechatronics and laser technology, which is an elective specialised course in other fields of study.

Jeziki/Languages:

Predavanja/Lectures:	Slovenščina
Vaje/Tutorial:	Slovenščina

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

Izpolnjevanje pogojev za vpis v Magistrski študijski program II. stopnje Strojništvo - Razvojno raziskovalni program.

Prerequisites:

Meeting the enrollment conditions for the Master's study programme of Mechanical Engineering - Research and Development program.

Vsebina:

1. Predavanje: Uvod
 - motivacija: učinkovitost, variabilnost
 - vrste avtomatizacije (toga, programabilna, fleksibilna),
 - uvajanje avtomatizacije.
2. Predavanje: Pregled osnovnih gradnikov
 - senzorji,
 - aktuatorji,
 - krmilniki,
 - industrijske komunikacije,
 - uporabniški vmesniki.
3. Predavanje: Robotski sistemi
 - specifikacije robota,
 - integracija,
 - končni aktuatorji,
 - zunanji senzorji,
 - tipične aplikacije.
4. Predavanje: Numerično krmiljeni sistemi
 - izvedbe,
 - karakteristike,
 - preračun NC pogona.
5. Predavanje: Avtomatizacija materialnih tokov
 - izhodišča,
 - tračnice, trakovi,
 - AGV sistemi.
6. Predavanje: Lokalizacija

Content (Syllabus outline):

1. Lecture: Introduction
 - motivation: efficiency, variability
 - types of automation (fixed, flexible, programmable),
 - automation migration strategy.
2. Lecture: Basic building blocks
 - sensors,
 - actuators,
 - controllers,
 - industrial data communications,
 - user interfaces.
3. Lecture: Robotic systems
 - robot specification,
 - integration,
 - end effectors,
 - external sensors,
 - typical applications.
4. Lecture: Numerically controlled systems
 - structure,
 - characteristics,
 - calculation of NC drive.
5. Lecture: Avtomation of material flow
 - basics,
 - rails, belts,
 - AGV systems.
6. Lecture: Localization
 - review of contact and contactless methods,
 - localization for CNC systems,

<ul style="list-style-type: none"> - pregled dotičnih in brezdotičnih metod, - lokalizacija za CNC sisteme, - lokalizacija izdelkov v razsutem stanju. <p>7. Predavanje: Kontrola procesov in izdelkov</p> <ul style="list-style-type: none"> - problem variabilnosti, - 100% vs. vzorčna kontrola, - obvladovanje procesov. <p>8. Predavanje: Sistemi za krmiljenje in nadzor delovnih sistemov</p> <ul style="list-style-type: none"> - SCADA, - MES, - nadzorni sistemi, - industrijski internet stvari. <p>9. Predavanje: Avtomatska identifikacija in zajem podatkov</p> <ul style="list-style-type: none"> - pregled metod, - črtne in QR kode, - RFID. <p>10. Predavanje: Uporaba slikovnih sistemov v avtomatizaciji</p> <ul style="list-style-type: none"> - osvetlitev in svetlobni efekti, - izbira kamere in izračun objektiva, - problematika nalaganja pri vzorčenju slike. <p>11. Predavanje: Posebnosti obdelave slik pri</p> <ul style="list-style-type: none"> - dimenzijski kontroli izdelkov, - iskanju površinskih napak, - lokalizaciji izdelkov, - sledenju šiva. <p>12. Predavanje: Umeritev slikovnih sistemov</p> <ul style="list-style-type: none"> - model kamere, - umeritev in razpačitev slike, - računanje koordinat v 3D prostoru. <p>13. Predavanje: Primeri uporabe slikovnih sistemov v avtomatizaciji</p> <ul style="list-style-type: none"> - kontrole dimenzij, - prepoznave površinskih napak, - sledenja šiva. <p>14. Predavanje: Avtomatizirane kontrolne priprave</p> <ul style="list-style-type: none"> - dotične kontrolne tehnike, - brezdotične kontrolne tehnike, <p>15. Predavanje: Zmožljivost sistemov avtomatizacije</p> <ul style="list-style-type: none"> - realno-časovno delovanje, - zanesljivost, 	<ul style="list-style-type: none"> - localization of objects with random poses. <p>7. Lecture: Process and product control</p> <ul style="list-style-type: none"> - variability, - 100% vs. sampling control, - process management and control. <p>8. Lecture: Systems for monitoring and control of production systems</p> <ul style="list-style-type: none"> - SCADA, - MES, - monitoring systems, - industrial internet of things. <p>9. Lecture: Automatic identification and data capture</p> <ul style="list-style-type: none"> - overview, - bar and QR code, - RFID. <p>10. Lecture: Imaging systems in automation</p> <ul style="list-style-type: none"> - illumination and light effects, - camera and lens selection, - image sampling and aliasing. <p>11. Lecture: Specifics of image processing at</p> <ul style="list-style-type: none"> - dimensional part inspection, - detection of surface defects, - part localization, - seam tracking. <p>12. Lecture: Imaging systems calibration</p> <ul style="list-style-type: none"> - camera model, - calibration and image correction, - calculation of 3D space coordinates. <p>13. Lecture: Example applications of imaging systems in automation</p> <ul style="list-style-type: none"> - dimension inspection, - surface defect detection, - seam tracking. <p>14. Lecture: Automated inspection devices</p> <ul style="list-style-type: none"> - contact inspection methods, - contactless inspection methods, <p>15. Lecture: Performance of automation systems</p> <ul style="list-style-type: none"> - real-time operation, - reliability, - availability, - security and connected standards.
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<ul style="list-style-type: none"> - razpoložljivost, - varnost in povezani standardi. 	
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Temeljna literatura in viri/Readings:

1. Automation, Production systems, and Computer-Integrated manufacturing, Mikell P. Groover, Pearson Prentice Hall, 2008 [COBISS.SI-ID [146606595](#)]
2. Handbook of intelligent sensors for industrial automation, Addison-Wesley, [COBISS.SI-ID [68180](#)]
3. Robotics, Vision and Control; Peter Corke, Springer, Berlin, Heidelberg 2011 [COBISS.SI-ID [15787291](#)]
4. Digital Image Processing using Matlab, Rafael C. Gonzalez, Pearson Prentice Hall, 2009[COBISS.SI-ID [11630875](#)]

Cilji in kompetence:

Cilji:

1. Spoznati uporabo avtomatizacije za izboljšanje produktivnosti in zmanjšanje variabilnosti v proizvodnji.
2. Spoznati integracijo osnovnih mehatronskih gradnikov v avtomatizirane sisteme.
3. Spoznati osnovne metode lokalizacije in identifikacije izdelkov.
4. Spoznati sintezo merilnih in mehatronskih sistemov pri avtomatiziranih kontrolnih pripravah.
5. Spoznati uporabo strojnega vida v avtomatizaciji in kontroli izdelkov.
6. Spoznati opredelitev zmogljivosti in varnosti avtomatiziranih sistemov.

Kompetence:

1. S2-MAG + P6-MAG: Uporaba avtomatizacije v proizvodnji za izboljšanje produktivnosti in obvladovanje variabilnosti
2. S2-MAG + P1-MAG: Sinteza mehatronskih gradnikov v avtomatizirane mehatronske sisteme.
3. S6-MAG + P6-MAG: Poznavanje metod lokalizacije in identifikacije objektov.
4. S2-MAG + P1-MAG: Sposobnost razvoja kontrolnih priprav.
5. S8-MAG + P1-MAG: Sposobnost uporabe strojnega vida.
6. S3-MAG + P1-MAG: Sposobnost

Objectives and competences:

Goals:

1. Understand the use of avtomation to improve productivity and reduce variability in production.
2. Understand the integration of basic mechatronic components in automated systems.
3. Understand the basic methods of localization and product identification.
4. Understand the synthesis of measuring and mechatronic systems in automated control devices.
5. Understand the use of machine vision in product automation and inspection.
6. Understand the definition of performance and security of automated systems.

Competences:

1. S2-MAG + P6-MAG: The use of avtomation to improve productivity and reduce variability in production.
2. S2-MAG + P1-MAG: Integration of mechatronic components in automated systems.
3. S6-MAG + P6-MAG: Understanding the basic methods of localization and product identification.
4. S2-MAG + P1-MAG: Development of inspection devices.
5. S8-MAG + P1-MAG: Use of machine vision.

analize zmogljivosti in varnosti avtomatiziranih sistemov.	6. S3-MAG + P1-MAG: Ability to analyse performance and security in automated systems.
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Predvideni študijski rezultati:	Intended learning outcomes:
<p>Znanja:</p> <p>Z1: Predmet je obravnava uporabo avtomatizacije za izboljšanje učinkovitosti in variabilnosti v proizvodnji, sintezo osnovnih gradnikov avtomatizacije, lokalizacijo, identifikacijo, avtomatizirane kontrolne priprave, uporabo strojnega vida, zmogljivost ter varnost v avtomatiziranih sistemih. S pridobljenimi kompetencami so študenti sposobni razvijati avtomatizirane sisteme.</p> <p>Spretnosti:</p> <ol style="list-style-type: none"> 1. S2.1 Razvoj specifikacij, sinteza osnovnih gradnikov avtomatizacije, programiranje in preizkušanje delovanja avtomatiziranih sistemov. 2. S2.2 Načrtovanje, izvedba in umerjanje avtomatiziranih kontrolnih priprav ter njihova integracija v industrijske informacijske sisteme. 3. S2.3 Uporaba strojnega vida za potrebe avtomatizacije in kontrole izdelkov. 	<p>Knowledge:</p> <p>Z1: The course deals with the use of automation to improve efficiency and reduce variability in production, synthesis of basic building blocks of automation, localization, identification, automated inspection devices, use of machine vision, performance and safety in automated systems. With the acquired competences, students are able to develop automated systems.</p> <p>Skills:</p> <ol style="list-style-type: none"> 1. S2.1 Development of specifications, synthesis of basic building blocks of automation, programming and testing of automated systems. 2. S2.2 Design, implementation and calibration of automated inspection devices and their integration into industrial information systems. 3. S2.3 Use of machine vision for automation and product inspection purposes.

Metode poučevanja in učenja:	Learning and teaching methods:
<p>P1 Avditorna predavanja s študijem primerov iz prakse ter z reševanjem izbranih teoretičnih in praktično uporabnih primerov.</p> <p>P2 Obravnava snovi po urejeni in vnaprej razloženi sistematiki.</p> <p>P4 Laboratorijske vaje z namenskim didaktičnim pripomočki: senzorji in aktuatorji, CNC sistemi, industrijskimi roboti, kontrolnimi pripravami in slikovnimi sistemi.</p> <p>P8 Izdelava in predstavitev aplikativnih seminarskih nalog.</p> <p>P14 Virtualni eksperimenti</p>	<p>P1 Classroom lectures by case study of selected theoretical and practical examples.</p> <p>P2 Structured and systematic lectures.</p> <p>P4 Laboratory exercises with dedicated teaching aids: sensors and actuators, CNC systems, industrial robots, control devices and imaging systems.</p> <p>P8 Design and presentation of practical seminars.</p> <p>P14 Virtual Experiments</p>

Načini ocenjevanja:**Delež/
Weight****Assessment:**

Teoretična snov (predavanja).	50,00 %	Theoretical matter (lectures).
Laboratorijsko delo na vajah (vključno s poročili).	20,00 %	Laboratory work in exercises (including reports).
Projektni seminar.	30,00 %	Project seminar.

Ocenjevalna lestvica:**Grading system:**

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Reference nosilca/Lecturer's references:**Drago Bračun:**

1. ŠKULJ Gašper, SLUGA Alojzij, **BRAČUN Drago**, BUTALA Peter, VRABIČ Rok. Energy efficient communication based on self-organisation of IoT devices for material flow tracking. CIRP annals, ISSN 0007-8506, 2019, vol. 68, iss. 1, str. 495-498. [COBISS.SI-ID [16704539](#)]
2. **BRAČUN Drago**, LEKŠE Igor. A visual inspection system for KTL coatings. 52nd CIRP Conference on Manufacturing Systems (CMS), 2019, (Procedia CIRP, ISSN 2212-8271, vol. 81). Amsterdam: Elsevier. 2019, vol. 81, f. 771-774. [COBISS.SI-ID [16688411](#)]
3. **BRAČUN Drago**, SLUGA Alojzij. Stereo vision based measuring system for online welding path inspection. Journal of materials processing technology, ISSN 0924-0136. 2015, vol. 223, str. 328-336. [COBISS.SI-ID [13971995](#)]
4. KENDA, Miha, KLOBČAR, Damjan, NAGODE, Aleš, **BRAČUN, Drago**. Analysis and prevention of weld crater cracking in circumferential laser microwelding of automotive pressure sensors. *Engineering failure analysis*. Oct. 2021, vol. 128, str. 1-14, [COBISS.SI-ID [69793539](#)]
5. KENDA, Miha, KLOBČAR, Damjan, **BRAČUN, Drago**. Condition based maintenance of the two-beam laser welding in high volume manufacturing of piezoelectric pressure sensor. *Journal of manufacturing systems*. Apr. 2021, vol. 59, str. 117-126 [COBISS.SI-ID [52913667](#)]