ವಿಶ್ವೇಶ್ವರಯ್ಯ ತಾಂತ್ರಿಕ ವಿಶ್ವವಿದ್ಯಾಲಯ
ವಿಟಿಯು ಅಧಿನಿಯಮ ೧೯೯೪ರ ಅಡಿಯಲ್ಲಿ ಕರ್ನಾಟಕ ಸರ್ಕಾರದಿಂದ ಸ್ಥಾಪಿತವಾದ ರಾಜ್ಯವಿಶ್ವವಿದ್ಯಾಲಯ

VISVESVARAYA TECHNOLOGICAL UNIVERSITY
State University of Government of Karnataka Established as per the VTU Act, 1994"JnanaSangama" Belagavi-590018, Karnataka, India

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REF: VTU/BGM/BOS/2023-24/284

DATE: 16 APR 2024

CLARIFICATION

The Updates made in the syllabus of the course/subject 21RA53-Autonomous Robot is only applicable to the program B.E./ B.Tech., in Robotics and Automation. Also, updates made in the syllabus of course/subject- BRA306B Robot Vision is applicable to both the program B.E./B.Tech., Robotics and Automation and B.E./B.Tech., in Automation and Robotics.

All concerned are hereby informed to make a note of the same.

16/04/24 B.E

REGISTRAR

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Ref. No. VTU/Aca/ 2022-23/ 5014 **Date:** 19 DEC 2023

CIRCULAR

Sub: Revised/Modified Syllabus of courses /subjects "Autonomous Robots -21RA53" and "Robot Vision-BRA306B" of Robotics and Automation UG Program regarding.

Ref: 1. Chairperson BOS in ME, VTU, Belagavi email dt: 17-12-2023.
2. Hon'ble Vice-Chancellors approval dated 19-12-2023.

This is to inform you all that, the UG syllabus of Automation and Robotics programme has been revised in the courses **21RA53- Autonomous Robot** and **BRA306A- Robot Vision** as there were feedbacks received from the stake holders w.r.t non- availability of certain study materials and reference books.

In view of this, the syllabus is been revised/modified to this extent and the modified version of the syllabus is attached with this circular to reference.

Hence, all the principles of engineering colleges, constituent college and chairpersons/Program coordinators of University departments are hereby informed to bring the content of this circular to the notice of the all concerned.

Thanking you.

Sd/-
REGISTRAR

Copy to,

1. The principals of engineering colleges, constituent college, VTU, Belagavi
2. The Chairperson/Program coordinator, University Department at Kalaburagi, Belagavi , Bengaluru and Mysuru.

Copy FWCs to:

1. The Registrar (Evaluation), VTU Belagavi, for information.
2. The Secretary to VC, VTU, Belagavi, for information.
3. The Director ITI, SMU VTU, Belagavi for information and request to upload the circular on VTU web portal.
4. The Special Officer, QPDS Examination Section, VTU, Belagavi for information
5. The Special Officer, Academic Section VTU, Belagavi for information
6. Office Copy

19/12/23

REGISTRAR

AUTONOMOUS ROBOTS			
Course Code	21RA53	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To learn principles of working of autonomous robots
- To learn the holistic design of autonomous robots - from the mechatronic design to sensors and intelligence.
- To demonstrate the sensing, perception, and cognition of autonomous robots
- To understand anatomy of autonomous robots
- To understand operation of Humanoid robot
- To understand principles of operation of telecheric robots

Teaching-Learning Process (General Instructions)

These are sample strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Adopt flipped classroom teaching method.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analyzing information.

Module-1

Introduction to Autonomous Robots

Introduction, Challenges of Mobile Autonomous Robots, Challenges of Manipulation , Locomotion and Manipulation:- Static and Dynamic Stability, Degrees of Freedom (example),

Mobile Robot Kinematics: Basic kinematics: Coordinate System and Frame Reference, Forward Kinematics of a selected mechanisms : Simple arm, Differential wheels Robots and Car-like steering, Inverse Kinematics of a selected mechanisms: Simple Manipulator Arm, inverse kinematics of Mobile Robots

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving./White board

Module-2

Path Planning and Navigation: Map Representations, Path Planning Algorithms, Sampling-based Path Planning, Path Smoothing, Planning at different length-scales. Navigation Architectures: Modularity for code reuse and sharing, control localization, Techniques for decomposition.

Localization & Mapping: The Challenge of Localization: Noise and Aliasing, Markov Localization**,** Particle Filter, The Kalman Filter, Probabilistic Map based Localization. SLAM, Covariance Matrix, EFK SLAM, Graph-based SLAM, RGB-D SLAM, RGB-D Mapping

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving.

Module-3

Sensors for Robots: Classification, Characterizing sensors performance, Motor sensors, Heading Sensors, Ground-based beacons, Active ranging, Motion/Speed Sensors, Vision-based sensors.

Vision: Image as two dimensional signals, from signals to information, basic image operation

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving.

Module-4

Decision Making and Autonomy: Representation Approaches, Decision Making, Case Study: Knowledge Representation and Decision Making. Procedural and Declarative Knowledge, Implications for perception design with example.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving.

Module-5

Navigation Agents and Arbitation: Physical Paths, Sonar, Fixed Light Beams, Lidar, Radar Imaging, Video, GPS. Guidelines for Selecting and deploying Navigation and collision avoidance sensors. Navigation agents.

Telecheric robots (Telerobots): Concepts of telerobotics, Applications, Control Architecture(Supervisory, Shared, direct and Bilateral Teleportation), Bilateral Control and force feedback (Position Control, Passive and stability, transparency and multichannel feedback, time delay and scattering theory, wave variables)

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk are used for Problem Solving. 4.The students will be organized into teams and each team will design a robot in order to address a specific application and challenge. The final challenges will be derived based on real-requirements of federal agencies or needs of specific industries.

Course Outcomes (Course Skill Set)

At the end of the course the student will be able to:

1. Demonstrate the sensing, perception, and cognition of autonomous robots
2. Understand anatomy of autonomous robots
3. Understand operation of Humanoid robot
4. Understand principles of operation of telecheric robots

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination (SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

1. First test at the end of 5th week of the semester
2. Second test at the end of the 10th week of the semester
3. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

3. First assignment at the end of 4th week of the semester
4. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

5. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module. 79/

The students have to answer 5 full questions, selecting one full question from each module. Marks scored out of 100 shall be reduced proportionally to 50 marks

Suggested Learning Resources:

Text Books Books :

1. Nikolaus Correll - Introduction to Autonomous Robots. Kinematics, Perception, Localization and Planning- Magellan Scientific (2016).
2. Autonomous Mobile Robots by Roland Siegwart, Illah Reza Nourbakhsh and Davide Scara-muzza.
3. Handbook of Robotics, second version edited by B. Siciliano, O. Khatib.

Reference Books :

1. Designing Autonomous Mobile Robots, John M Holland, Elsevier, 2004
2. Autonomous Mobile Robots, Edited by Shuzhi Sam Ge, Frank L Lewis, Taylor and Francis, 2006
3. Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", MIT Press, 2nd Edition, 2011.
4. Telerobotics, Springer Handbook of Robotics pp741-757, 978-3-540-30301-5,2016, Günter Niemeyer Dr. , Carsten Preusche or Gerd Hirzinger Dr. .

Web links and Video Lectures (e-Resources):

- http://www.kostasalexis.com/autonomous-mobile-robot-design.html

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

The students will be organized into teams and each team will design a robot in order to address a specific application and challenge. The final challenges will be derived based on real-requirements of federal agencies or needs of specific industries.

Robot Vision		Semester	III
Course Code	**BRA306B**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	**3:0:0:0**	SEE Marks	50
Total Hours of Pedagogy	**40 Hours**	Total Marks	100
Credits	**03**	Exam Hours	03
Examination nature (SEE)	**Theory**		

Course Objectives:

The objectives of this course are:

1. To learn fundamental Digital image processing in vision systems.
2. To learn vision based Image Formation, Sensing, Segmentation & Analysis.
3. To be familiar about the applications regarding vision.

Teaching-Learning Process (General Instructions)

1. These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.
2. The lecturer's approach (L) does not have to be limited to traditional methods of teaching. It is possible to incorporate alternative and effective teaching methods to achieve the desired outcomes.
3. Utilize videos and animations to illustrate the functioning of different techniques used inthe manufacturing of smart materials.
4. Foster collaborative learning exercises within the classroom to encourage group participation and engagement.
5. Pose a minimum of three Higher Order Thinking (HOT) questions during class discussions to stimulate critical thinking among students.
6. Implement Problem-Based Learning (PBL) as an approach that enhances students' analytical skills and nurtures their ability to design, evaluate, generalize, and analyzeinformation, rather than solely relying on rote memorization.

Module-1

Introduction to Robot Vision:

Overview of robot vision and its applications, Illumination, Image formation-elementary optics, Camera Sensors, Camera Interface and video standards, Characteristics of camera sensors.

Image Acquisition and representation: Sampling and Quantization, inter-pixel distances, Adjacency conventions, Image acquisition hardware, speed consideration.

8 Hours

Module-2

Digital Image Processing:

Fundamental steps in Digital image Processing, Components of an Image Processing System, Example of fields that use Digital Image Processing, Elements of Visual Perception(Structure of the Human Eye, Image formation in the eye, Brightness Adaption and Discrimination), Light and the Electromagnetic Spectrum, Image Sensing and Acquisition(Single Sensor, Sensor Strips, Sensor Arrays)

8 Hours

Module-3

Introduction to image understanding: Representations and information processing: from images to object models, Organization of visual processes, Visual representations(The raw primal sketch, the full primal sketch, the two-and-a-half-dimensional sketch, three- dimensional model)

Image Formation & Sensing: Aspects of Image Formation, Brightness, Lenses. Image Sensing: Sensing Color, Randomness and noise, Quantization of the Image.

8 Hours

Module-4

Regions & Image Segmentation: Thresholding Methods, Histograms, Spatial Coherence, Image Segmentation, Using Colour, Merging and Splitting.

Image Analysis: Introduction (Inspection, Location and Identification), Template matching, Decision-theoretic approaches, The Hough Transform.

8 Hours

Module-5

Robot Vision in Manufacturing: Application Categories (Types of Production, Evaluation, Value-Adding Machine Vision), System Categories, Integration and Interfaces, Mechanical Interface, Electrical Interface, Temporal Interfaces, Human-Machine Interfaces.

8 Hours

Course Outcome (COs) (Course Skill Set)

At the end of the course, the student will be able to :

CO1: Understand the fundamentals of robotics and its applications. CO2:
Give an understanding of image processing for computer vision
CO3: Focus on early processing of images and the determination of structure: edges, lines, shapes CO4:
Apply computer vision to recognize objects, its trajectory and the basics of visual learning for the purpose of classification.
CO5: Learn the applications of vision system in modern manufacturing environment

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Testcomponent, there are 25 marks.
2. The first test will be administered after 40-50% of the syllabus has been covered, and the second testwill be administered after 85-90% of the syllabus has been covered
3. Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then onlyone assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
4. For the course, CIE marks will be based on a scaled-down sum of two tests and other methods ofassessment.
5. Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per theoutcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours**).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), should have a mix of topics under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Textbooks:

1. (MIT Electrical Engineering and Computer Science) Berthold K.P. Horn - Robot Vision-MIT Press (1986)
2. David Vernon, Machine vision –automated visual inspection and robot vision, Prentice Hall, 1991
3. Alexander Hornberg, Handbook of Machine Vision, Wiley, 2006

Reference Books/Jornal:

1. Rafael C. Gonzales, Richard.E.Woods, Digital Image Processing, Pearson Education, 2008
2. Alexander Hornberg, Handbook of Machine and Computer Vision, 2nd Edition, Wiley, 2017.

Web links and Video Lectures (e-Resources):

1. https://www.baslerweb.com/en/vision-campus/markets-and-applications/robots-with-vision-technology/
2. https://new.abb.com/products/robotics/application-equipment-and-accessories/vision-systems
3. www.vision-systems.com
4. www.invision-news.de

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. Quizzes
2. Assignments
3. Worksheets
4. Vision-Based Learning from Demonstration System for Robot Arms