Image Analysis and Computer Vision

CCOM, UPR Río Piedras

Digital images and videos are now used everywhere:
smartphones, social networks, self-driving cars, sciences…

This course presents an introduction to the main tools in **image processing, machine learning and geometrical modeling** that enable us to get the computer to analyze them and **extract information automatically**.

Automatic face **detection** and **identification**

Semantic image **segmentation**

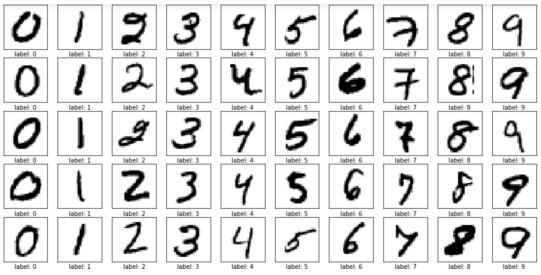
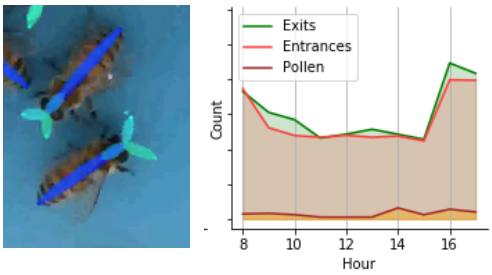


Image **classification**



Honeybees **tracking** for automatic colony monitoring

Image **filtering**

Automatic image **alignment**

Any question?

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http://ccom.uprrp.edu/~rmegret/teaching

*Practice labs in **python**, using skimage, sklearn, openCV, tensorflow/Keras libraries. Available for term project: GPU server, Google Coral, NVIDIA Jetson…*

University of Puerto Rico
Río Piedras campus
College of Natural Sciences
Computer Science Department
Undergraduate program

1. **Title –Computer Vision / Visión Artificial**

2. **Course Code – CCOM4995-??? (temporary code)**

3. **Credits – 3**

4. **Pre-Requisites, Co-Requisites and other Requirements**
   - Data Structures (CCOM 3034)

5. **Course Description**

   Elective course designed for senior undergraduate students in Computer Science, organized as lectures with programming and interactive exercises. Computer Vision is about the algorithms and models that enable machines to extract information automatically from images and videos. This course provides an introduction to computer vision through the study of three main aspects of the domain: image processing at the pixel level, machine learning of visual models, estimation of geometrical models. Each topic will be associated with practical programming laboratories with applications such as image segmentation, image alignment, and object recognition.

6. **Learning Objectives**

   At the successful completion of the class, the students will be able to
   - Explain how computer vision technologies are used in applications such as face recognition, self-driving cars, and human-machine interfaces
   - Manipulate images programmatically and perform basic image processing tasks
   - Apply machine learning for image segmentation and visual recognition
   - Estimate geometrical parameters automatically from images
   - Explain the technical design of computer vision software
   - Design and implement software programs that use and integrate these competencies
   - Identify the potential and limits of computer vision technologies and its impact on society

7. Content Outline and Time Distribution

Topics	Time (h)
I. Image Processing ● Image representation and manipulation ● Segmentation ● Filtering	12h
II. Machine learning of visual models ● Learning image segmentation ● Object and scene recognition ● Convolutional Neural Networks and Deep Learning	12h
III. Geometry modeling and estimation ● Camera modeling and image formation ● Geometric image transformation and alignment ● Principle of stereovision and 3D vision	12h
Literature review project	3h
Final project	6h
Total	45h

8. Instructional Techniques

Concepts and theory presented in conferences involving interactive in-class discussions.
Hands on laboratories using a scripting language (such as python or Matlab) coupled with computer vision and machine learning libraries.
Practice trained through assignments that combine theoretical questions and software implementation in relation to the learning objectives.
Integration of knowledge and analysis of the impact on individual and society through a literature review Project and a final Project.

9. Minimum Available or Required Resources

Laboratories require computers with good graphics capabilities.
Software: scripting language with computer vision and machine learning libraries (such as python, with OpenCV, skimage, sklearn, keras... or Matlab).
Fast network to take advantage of remote computing on supercomputing servers (e.g. NSF XSEDE network or UPR High-Performance Computing facility).
Content and software resources will be distributed online (e.g. through Moodle). Most assignments will rely on multi-platform software that can be installed on student's computers to facilitate the programming assignments.

10. Evaluation Techniques

Participation in class and hands-on laboratories	10%
3 assignments (theory + software implementation)	15% each
1 litterature review project (oral presentation)	15%
1 final project (oral presentation + report + software)	30%

11. Special Accommodation

The University of Puerto Rico complies with federal and state laws, norms and regulations about discrimination including the American Disabilities Act 1990 (ADA) and Law 31 Commonwealth of Puerto Rico. Students receiving services from Vocational Rehabilitation must communicate with his or her professor at the beginning of the course in order to plan reasonable accommodations and necessary assistive equipment following recommendations from the Office of People with Disabilities Affairs (OAPI in Spanish) located at the Dean of Students Affairs. Students with special needs who require any type of assistance or accommodation must communicate with his or her professor at the beginning of the course as well.

12. Institutional policy against sexual harassment.

The University of Puerto Rico prohibits discrimination based on sex and gender, in all its forms, including sexual harassment. According to the institutional policy against sexual harassment at the University of Puerto Rico, Certification Number 130 2014-2015 of the Governing Board, if a student is being or was affected by conduct related to sexual harassment, he / she may go to the Office of the Student Attorney. (787-764-0000, extensions 86600, 86601 or 86603), the Student Deanship (extension 86000) or the Title IX compliance coordinator (extensions 84013 or 84005) for guidance and / or filing a complaint.

13. Academic Integrity

The University of Puerto Rico promotes the highest standards of academic and scientific integrity. Article 6.2 of the General Student Regulations of the UPR (Certification No. 13, 2009-2010, Board of Trustees) states that "academic dishonesty includes, but is not limited to: fraudulent actions, obtaining grades or academic degrees using false or fraudulent simulations, copying in whole or in part the academic work of another person, totally or partially plagiarizing the work of another person, copying totally or partially the answers of another person to the questions of an examination, doing or getting another person to take on their behalf any oral or written test or examination, as well as assistance or facilitation for another person to engage in said conduct. " Any of these actions will be subject to disciplinary sanctions in accordance with the disciplinary procedure established in the General Regulations of Students of the UPR in force.

14. Grading System A, B, C, D, F

15. Bibliography

No textbook required, as most content will be provided by the professor, through the conferences and hands-on laboratories. The following books will be used as a complement (available online):

- Richard Szeliski. "Computer Vision: Algorithms and Applications". Springer 2010. ISBN 1848829345. Available online: http://szeliski.org/Book/
- Ian Goodfellow, Yoshua Bengio and Aaron Courville. "Deep Learning". MIT Press, 2016. Available online: http://www.deeplearningbook.org/
- Jan Erik Solem. "Programming Computer Vision with Python: Tools and algorithms for analyzing images". O'Reilly, 2012. ISBN 1449316549. Draft available online: http://programmingcomputervision.com/downloads/ProgrammingComputerVision_CCdraft.pdf
- Wilhelm Burger and Mark J. Burge, Principles of Digital Image Processing: Fundamental Techniques, Springer, 2011. ISBN 1848001908.
- Fletcher Dunn, Ian Parberry, 3D Math Primer for Graphics and Game Development, 2nd Edition. CRC Press, 2011. ISBN 1568817231.

Electronic references

- Course page: http://ccom.uprrp.edu/~rmegret/teaching/computervision.html
- OpenCV (Computer Vision library) official page: http://opencv.org/ and its documentation http://docs.opencv.org/3.2.0/
- Scikit-image (Image Processing library): http://scikit-image.org/docs/dev/
- Scikit-learn (Machine learning library): http://scikit-learn.org/stable/documentation.html
- Keras (Python Deep Learning library) official page: https://keras.io/
- Matlab - Image Processing and Computer Vision System Toolboxes: https://www.mathworks.com/products/image.html, https://www.mathworks.com/help/vision/