NATIONAL INSTITUTE OF PHYSICS
College of Science
University of the Philippines, Diliman, Quezon City

PHYSICS 301 - SPECIAL TOPICS IN EXPERIMENTAL PHYSICS (ADVANCED SIGNAL AND IMAGE PROCESSING)

A. Course Catalogue Description

1. **Course number:** Physics 301
2. **Course Title:** Physics 301 - Special Topics in Experimental Physics (Advanced Signal and Image Processing)
3. **Course Description:** Methods for analysis of high-dimensional image signals
4. **Prerequisite:** None
5. **Semester Offered:** 1st and 2nd semester
6. **Course Credit:** 3 units
7. **Number of Hours:** 3 h / wk
8. **Course Goals:**
   Acquire advanced skill and knowledge in feature extraction, signal processing, compression, and analysis of high-dimensional image signals.

B. Rationale

High-dimensional image signals include video, multi- or hyperspectral imagery, and 3D imagery. With increasing capacity in imaging, digital storage and computing power comes the need for tools to be able to extract information from such images. The techniques in this course can be used not only on images but also on other multivariate signals.

C. Course Outline

1. Course Outcomes (CO)

Upon completion of the course, students must be able to:

CO 1. Explain how different high-dimensional images are captured
CO 2. Extract measurements from high-dimensional signals.
CO 3. Use different image compression techniques
CO 4. Implement 3D imaging algorithms

2. Course Content

Lecture Topics	No. of Hours
1. Review of High-dimensional Image Capture Techniques a. Multi- and Hyperspectral imaging b. Video c. 3D	3
2. Multi- and Hyperspectral Imaging a. Color processing b. Spectral imaging c. Principal Components Analysis for Compression d. RGB to Spectra	15

3. Video a. Tracking b. Compression c. Finding scenes	15
4. 3D Imaging a. Shape from stereo b. Shape from structured light c. Shape from shadows	15

3. Course Coverage

Hours	CO	TOPIC	ESSENTIAL/ KEY QUESTIONS	Suggested Teaching and Learning Activities	Suggested Assessment Tools
3	CO.1	Review of high-dimensional image capture techniques	What are the techniques for capturing high-dimensional images?		
Multi- and Hyperspectral Imaging					
2.5	CO.2	Color Processing	When is color useful for image segmentation?	Image segmentation	Report
2.5	CO.2	Spectral Imaging	What spectral image databases are available?	Rendering of hyperspectral images	Report
5	CO.3	Principal Component Analysis for Compression	When is PCA appropriate to be used?	PCA applied to hyperspectral images	Report
5	CO.2	RGB-to-Spectra	How can spectral information be derived from digital color (RGB)?	Spectral superresolution	Report
Video					
5	CO.2	Tracking	How can an object of interest be tracked from video?	Tracking regions of interest in video using color	Report
5	CO.3	Compression	How are videos compressed?	MPEG-4 Application	Report
5	CO.2	Finding Scenes	How are scenes found from video?	Scene detection by graph modeling	Report
3D Imaging					
5	CO.2, CO.4	Shape from Stereo	How is depth information obtained from stereo-pairs?	Stereometry	Report
5	CO.2, CO.4	Shape from Structured Light	How is surface information embedded in reflected light?	Phase-shift profilometry	Report

5	CO.2, CO.4	Shape from Shadows	How is shape information derived from the image of a surface illuminated at different light source locations?	Photometric Stereo	Report

4. **Course Requirements**

   Reports - 100%

5. **Guidelines**

   a. **Mode of delivery.** Synchronous classes will be every Wednesday 5:30-7pm unless it is necessary to move the class on Friday. An announcement will be made about it.

   b. **Online classes.** Our recurring zoom link for synchronous classes is https://up-edu.zoom.us/j/84801529618

      Meeting ID: 848 0152 9618
      Passcode: Ph301Class

   c. **Tutorials.** I can conduct tutorials on Fridays 5:30-7 upon request.

   d. **Programming.** Recommended programming language is MATLAB. Use your up.edu.ph email account to access the university-wide MATLAB license at https://www.mathworks.com. You can download the installer or use Matlab online. You may use other programming languages, however, my instructions and tutorials will be in Matlab.

   e. **Learning Management System**. You have been automatically enrolled in UVLE. If you have not used or activated your UVLE before, please follow the instructions found in https://youtu.be/x0_jBwUbltw

   f. **Reports**. Reports will be in presentation style. (Powerpoint, Google slides, or PDF). The reports will be 100% of your grade. The presentation sections are ***Objectives***, ***Method***, ***Experimental Setup*** (if the activity requires one), ***Results***, ***Analysis***, ***Reflection***- a short narrative why you think your results are valid or correct, how you felt about the activity (did you enjoy it, was it tedious), what went right or wrong with your experiment, and ***Self-grade***.

   g. **Self-grade**. At the end of your report you will give yourself a grade following the rubric below. Your self-grade is final if I agree with it, otherwise I'll change it to what I think is a more appropriate score.

RUBRIC FOR REPORT GRADE

CRITERIA	QUALIFICATIONS	SCORE
Technical correctness	☐ Met all objectives. ☐ Results are complete. ☐ Results are verifiably correct. ☐ Understood the lesson.	30
Quality of presentation.	☐ All text and images are of good quality. ☐ A picture or diagram of the setup is shown (if the activity has one). ☐ Code has sufficient comments and guides. ☐ All plots are properly labeled and are visually understandable.	30

	☐ The report is clear.	
Reflection	☐ Explained the validity of results. ☐ Discussed what went right or wrong in the activity. ☐ Justified the self score. ☐ Acknowledged sources (e.g. persons consulted, references, etc.)	30
Ownership	☐ Applied the technique on other data ☐ Discovered limitations in the technique ☐ Introduced improvements to the technique	10

h. **Grade Equivalent for Raw Score X**

X >= 95	: 1.0	75 <= X < 80	:	2.0	X < 60	:	3.0
90 <= X < 95	: 1.25	70 <= X < 75	:	2.25			
85 <= X < 90	: 1.5	65 <= X < 70	:	2.5			
80 <= X <85	: 1.75	60 <= X < 65	:	2.75			

REFERENCES:

1. Introductory techniques for 3D computer vision, Trucco and Verri, 1998
2. An introduction to 3D computer vision techniques and algorithms, Cyganek and Siebert, 2009
3. Hyperspectral Imaging Remote Sensing: Physics, Sensors and Algorithms, Manolakis, 2016
4. Advanced Color Image Processing and Analysis, Maloigne (Editor), 2013
5. Multidimensional Signal, Image and Video Processing, Woods 2011
6. Advanced Image and Video Processing Using MATLAB, Gong et al. 2019
7. Del Fabro, Manfred, and Laszlo Böszörmenyi. "State-of-the-art and future challenges in video scene detection: a survey." *Multimedia systems* 19, no. 5 (2013): 427-454.