Color and spectral Imaging

5 ECTS **UJM semester 3**

Course instructor: Prof. Alain Trémeau
Language of instruction: English

Overview

The color appearance of the objects is influenced by the geometry of the illumination, the three-dimensional structure of the objects, and the surface reflectance properties of their materials. The objective of this course is to understand from case studies the main effects of object properties on color description

Multispectral imaging (MSI) devices are constructed to acquire a sequence of reflectance images on a number of non-contiguous spectral bands which are usually selected by means of a suitable set of filters. The diversity of MSI systems cited in the state of the art demonstrates the importance of having a good understanding of all elements of the data acquisition and processing chain to provide accurate and precise answers to end users questions and concerns.

It exists also different types of 3D scanning techniques to get a precise digital model of an object. In some applications the 3D data can be combined with high resolution images captured with MSI cameras. In this course we will survey the different acquisition systems and methodologies that can be used to 3D and 2D multispectral data. We will review solutions proposed in the state of the art to solve registration and alignment problems. We will show how the acquisition system and the set-up can affect the resulting data, we will show that the accuracy of acquired data depends also of how the system is used and how data are processed. We will focus on the various sources of error and of instabilities. We will illustrate the course by several examples related to different application domains.

Learning outcomes

On successful completion of this course, students should have the skills and knowledge to:

- Understand and master basic knowledge, theories and methods related to Color/Spectral in Imaging/Computer Vision;
- Identify, formulate and solve practical problems related to the use of Color/Spectral Imaging systems;
- Critically review and assess scientific literature in the field and apply theoretical knowledge to identify the novelty and practicality of proposed methods.
- Design and develop practical and innovative Color/Spectral Imaging applications or Computer Vision systems.
- Conduct themselves professionally and responsibly in the areas of Color/Spectral Imaging/Computer Vision.

Content

- Color and goniocolorimetry: The interaction of light /and color.
- Measuring color/spectral quality: principles and applications of setting instrumental color/spectral tolerances.
- Case study 1: Color appearance of real objects varying in material, hue, and shape.
- Case study 2: Effects of materials on the color appearance of real objects: Observation and Measurement of the Appearance of Metallic Materials.
- Case study 3: Characterization of color appearance with a multi-angle device: Visual perception and measurement of Coil Coating Materials and Surfaces.

- Case study 4: Characterization of the color gamut of a laser printing system and calibration of the measurement system.
- Case study 5: Review of acquisition systems coupling Multispectral Imaging and 3D Imaging

Teaching methods

- Lectures: 18 hours
- Practical work: 18 hours
- Project work: 18 hours

Study materials

- R.S. Berns, Principles of color technology, 3rd edition, Wiley Interscience, New York, 2000
- Martin Giesel and Karl R. Gegenfurtner, Effects of material on the color appearance of real objects, Journal of Vision, August 2, 2010 vol. 10 no. 7 article 452.
- Mikula, M., Čeppan, M. and Vaško, K. (2003), Gloss and goniocolorimetry of printed materials. Color Res. Appl., 28: 335–342
- Martin Giesel and Karl R. Gegenfurtner, Color appearance of real objects varying in material, hue, and shape, *Journal of Vision* September 30, 2010 vol. 10 no. 9 article 10
- Maria Olkkonen, Thorsten Hansen, Karl R. Gegenfurtner, Color appearance of familiar objects: Effects of object shape, texture, and illumination changes, Journal of Vision, (2008) 8(5):13, 1–16.
- Elena González, Francesco Bianconi, Marcos X. Álvarez, and Stefano A. Saetta, Automatic Characterization of the Visual Appearance of Industrial Materials through Colour and Texture Analysis: An Overview of Methods and Applications, Advances in Optical Technologies, Volume 2013, Article ID 503541, 11 pages, http://dx.doi.org/10.1155/2013/503541.
- McCamy, C. S. (1998), Observation and measurement of the appearance of metallic materials. Part II. Macro appearance. Color Res. Appl., 21, 4: 292–305.
- McCamy, C. S. (1998), Observation and measurement of the appearance of metallic materials. Part II. Micro appearance. Color Res. Appl., 23: 362–373.
- José M. Medina and José A. Díaz, Scattering characterization of nanopigments in metallic coatings using hyperspectral optical imaging, Applied Optics, Volume 50, Issue 31, Page g47.
- F. L. S. Cuppo, A. García-Valenzuela and J. A. Olivares, Influence of surface roughness on the diffuse to near-normal viewing reflectance factor of coatings and its consequences on color measurements, Color Research & Application, Volume 38, Issue 3, June 2013, Pages: 177–187.
- Lionel Simonot and Mady Elias, Color change due to surface state modification, Color Research & Application, Volume 28, Issue 1, February 2003, Pages: 45–49,
- Sofie Ignell, Ulf Kleist and Mikael Rigdahl, On the relations between color, gloss, and surface texture in injection-molded plastics, Color Research & Application, Volume 34, Issue 4, August 2009, Pages: 291–298,
- Leloup, F. B., Obein, G., Pointer, M. R. and Hanselaer, P. (2013), Toward the soft metrology of surface gloss: A review. Color Res. Appl.. doi: 10.1002/col.21846.
- Barton L. Anderson, Visual perception of materials and surfaces, Current Biology, Volume 21, Issue 24, 20 December 2011, Pages R978–R983.
- X-rite: Characterization of Automotive Color and Appearance utilizing an under-sampled BRDF (bi-directional reflectance differential function) and new hand held Multi-angle Spectrophotometry.
- Laurence T. Maloney and David H. Brainard, Color and material perception: Achievements and challenges, *Journal of Vision* December 23, 2010 vol. 10 no. 9 article 19.

Assumed Knowledge

- Knowledge of Optical Geometry, Radiometry and Color Science fundamentals.
- Knowledge of Matlab.
- Previous knowledge of digital image processing will be helpful, but is not essential.

Evaluation criteria

- Written exam 40%
- Written assignments / Labs 30%
- Project work 20%
- Seminar presentations 10%