Infrared vision of artworks based on web cameras: a cross-disciplinary laboratory of optics

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Abstract. Applied optics offers a way to teach fundamental concepts of light properties and radiation-matter interaction through interdisciplinary experimental activities. In this framework, we designed a cross-disciplinary laboratorial activity on optics applied to artworks based on DIY instrumentation for the secondary school level. The teaching sequence includes inquiry-based seminars and laboratorial activities on imaging, spectrometry, infrared applications to conservation science.

1 Introduction

Recently, Modern Physics has become part of the curriculum of secondary school in Italy. Applied optics offers a way to teach fundamental concepts of light properties and radiation-matter interaction through interdisciplinary experimental activities. Moreover, a number of optical experiments may be designed using Do-It-Yourself (DIY) materials, including sources, lenses, and web camera equipped with CCD-technology sensor.

In this work, we present laboratory dedicated to optical non-destructive techniques for Cultural Heritage, following an interdisciplinary approach whose educational value is highlighted by international literature [1-3]. The aim is to provide the students a deeper understanding of physical concepts regarding optics and electromagnetic waves by proposing a charming, practical and stimulant approach.

The teaching proposal was developed by the laboratory OpDATeCH (Optical Devices and Advanced Techniques for Cultural Heritage) of the University of Verona in the framework of the "Progetto Lauree Scientifiche", promoted by the Italian Ministry of Education, University and Research. The course is proposed to 25 students from fourth and fifth year of two Scientific High Schools of Verona.

The experimentation with the students is ongoing and we will present the first results at the GIREP conference.

2 Description of the teaching proposal

The total duration of the activity is of 18 hours in six lessons, each one including a theoretical part followed by an inquiry-based practical laboratory. Students are called to design and to assemble optical instrumentation, to provide the outcomes of simple experiments, and to compare the effective results with their previsions (typical POE cycle). The objectives are presented in the form of problem solving: the students are helped, when needed, or advised, but not guided step-by-step. The role of the teachers is then limited to supervision and assistance in the interpretation and assimilation of results.

The **first lesson**, after a presentation of the field of Cultural Heritage conservation, focuses on light and on geometrical optics. Reflection and refraction are recalled, and the ray-optics approximation highlighted. During the laboratory session, the students work with didactic optics kits approaching experiments on formation of images in the visible range. A parallelism between the optical setups and the human eye is also discussed.

The **second lesson** analyses the concept of colour perception and synthesis from the artistic and from the scientific point of view by presenting historical studies. Then, the concepts of light decomposition and spectrometry are explained. By exploiting simple and low-cost DIY instrumentation [4], the students are asked to build an optical spectrometer, and to use it for investigate the emission spectra of different sources. Last step is to analyse the reflectance spectra by introducing a commercial visible spectrometer.

The **third lesson** is designed as a seminar on application case studies with the aim to provide an overview of the potentialities of the above optical methods, showing the connection between the physical phenomena concerning radiation-matter interaction and conservation.

The last **three lessons** constitute the single sub-laboratory specifically dedicated to the infrared vision of artworks. The idea is to design the infrared reflectography technique in a DIY modality by modifying a web camera sensor: the setup is re-invented in a didactical perspective, allowing the students to implement it by themselves. Finally, Students are asked to carry out the infrared experiment, working autonomously. In this last step they process the images in order to build up infrared false colour representations using an open-source image editing software.

3 Final remarks

In the framework of the teaching of Modern Physics to secondary school students in Italy, we have designed an original cross-disciplinary formative intervention connecting optics and spectrometry to cultural heritage applications through hands-on activities and POE methodology. The experimentation with students is still in progress and we will present the preliminary results in the GIREP conference.

Infrared reflectography experiment with a web camera on a painting mock-up .

References

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