EE491 Project (3-0)

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PROJECT 1

Project title:

Developing an interactive simulation tool with enhanced GUI to evaluate the state of polarization along an optical system

Context:

Polarization is defined as the path drawn by the tip of the electric field vector as a function of time at a given location. Optical components like optical fiber, wave-plates, Faraday mirror, etc. manipulate the state of polarization. Jones formalism describes the polarization properties of light and the optical components mathematically. Therefore, an optical system formed by cascaded numerous components can be modelled via Jones formalism.

Abstract:

Visualization of the polarization state belonging to an optical wave passing through various components can help students to better understand how those components impact the initial state of polarization. There is a need for an interactive simulation tool that has an easy-to-use graphical user interface (GUI) to be used in classes. The user must be able to define its own components as well as their particular combinations to form a user-defined optical system. The tool must provide a graphical illustration of polarization state according to the parameters of the input light and the optical system.

Task list:

T1. Learning about polarization concepts, birefringence and Jones formalism (W1-W5).

T2. Deciding which parameters can describe a state of polarization and how they can be asked in a user-friendly interface. Designing the interface in which the polarization state can be drawn (W1-W5).

T3. Writing the code to draw state of polarization with respect to the asked parameters (W3-W6).

T4. Deciding which optical components may be used to form an optical system. What are the general parameters that define the response of the component? How the user can generate its own component by specifying those parameters? (W6-W8)

T5. Designing the interface for the formation of an optical system (W8-W14).

T6. Writing the code for such an optical system simulator (W8-W14).

Pre-requisites:

- Enthusiasm to design, code and create a new educational simulation tool that would be used for years in related classes.
- Proficiency in one of the following languages: MATLAB, Phyton, C++
- Familiarity to matrix operations and wave optics.
- Desire to learn about electromagnetic and polarization optics.
- Taking the course EE411 (Fundamentals of Photonics) is recommended (not obligatory).

PROJECT 2

Project title: Probe Pulse Coding in FBG assisted ϕ-OTDR Systems

Context:

Distributed acoustic sensing (DAS) is a fiber-optic sensing technique based on the detection of Rayleigh backscattered light in optical fibers. In fiber-optic (FO) cable subjected to acoustic vibrations, the phase and amplitude of the Rayleigh backscattered signal changes. DAS systems interrogated by F-OTDR (Phase- sensitive Optical Time Domain Reflectometer) has become an extremely popular research area and experienced the fastest transition into commercialization due to the great potential in adapting this technology in real-life applications such as seismic, oil well, railway trackside, and asset monitoring systems. The use of existing fiber optic cables as a seismic sensor network via DOFS (also called **photonic seismology**) is of critical importance, especially for the countries located in earthquake zones.

Abstract: In the last decade, implementation of FBGs into ϕ-OTDR systems has gained popularity in order to improve inherently weak Rayleigh scattering signal. Pulse modification is another approach used in these systems with the same aim. In this project, the aim is to analyse FBG-assisted ϕ-OTDR systems with modified probe pulses.

Task list:

T1. Learning about distributed fiber optic sensors and fiber Bragg gratings (W1-W5).

T2. Development of a basic FBG-assisted ϕ-OTDR simulator (W5-W10)

T3. Modification of probe pulse by using Golay codes (W10-W14).

T4. Analysis of FBG use related problems in ϕ-OTDR systems (W10-W14).

Pre-requisites:

- -Experience in C++ and/or MATLAB
- Taking the course EE411 (Fundamentals of Photonics) is recommended (not obligatory).
- Listening EE513 might help the student in getting background information.

PROJECT 3

Project title:

Feasibility analysis of a sensor-assisted industrial heating system

Context:

High safety, durability and low energy consumption are the main concerns of industrial applications today.The food industry is one of the most strategic areas. Industrial microwave ovens are designed to heat food efficiently, quickly and evenly. Not only food, but drying, tempering or heating different objects need this type of process for different reasons. Microwaves can easily form standing waves inside the cavity causing cold spots on the product. These cold spots cannot be heated to the desired level and may result in insufficient product output quality. In addition, electric arcs due to a dense electric field are very common in microwave ovens. These arcs can easily start a fire and cause serious damage.

Abstract:

This project aims to realise the feasibility analysis of a novel platform comprising an industrial microwave oven and a monitoring unit. The monitoring unit will be based on fiber optic sensor technology (Fiber Bragg Gratings, FBGs).

Task list:

T1. Write a complete State of the art about Microwave Heating systems. (W1-W5).

T2. State of the art about using optical and/or fiber optic sensors in Microwave Heating systems.

What are the existing monitoring systems (used in microwave ovens) rather than optical sensors? What are the fiber-optic-based monitoring systems implemented in industrial microwave heating systems. Realise a complete search from the literatüre (W1-W5).

T3. Writing the code to simulate the power distribution inside the microwave oven for a given configuration (W3-W8).

T4. Feasibility of using FBG sensors for measuring heat distribution inside the microwave heating system. How can you define and determine the sensor parameters? (W6-W8)

- Distance between FBGs.
- FBG parameters (reflectivity, grating pitch, grating length, fiber type,…)
- Total number of FBGs

T5. Designing the whole system for the quasi-distributed temperature measurement inside the oven (W8-W14).

T6. Writing the code for the DAQ interface (W8-W14).

Pre-requisites:

- Enthusiasm in literature search.
- Proficiency in one of the following languages: MATLAB, Phyton, C++
- Desire to learn about fiber optic sensors.

- Taking the courses EE425 (Microwave Engineering) and EE411 (Fundamentals of Photonics) is recommended.

Note: For the student(s) who will show a great success upon selecting Project 3, an opportunity to realize a master thesis on the same topic will be available.