Building NIR Imaging Device

Objective: The objective of the proposed project is to develop a near infrared (NIR) imaging device for detection of cracks or defects beneath painted metal surfaces. The proposed research will be carried out by my students and me at Stuyvesant High School.

Background:

The ability to image corrosion beneath paint is limited by light reflection, absorption, and scattering from the paint. Photons propagating in turbid media have their incident direction, polarization, and phase randomized by multiple scattering. The degree of depolarization depends on the initial polarization state, the number of scattering interactions, the anisotropy of each scatter, and the properties of the surrounding medium. Various defects in highly scattering medium at certain depths can be detected using an optical technique based on spectral, temporal and polarization properties of the scattered light from a turbid media such as paint. Wavelengths in the far-red and near-infrared range can penetrate paint layers and can be used to investigate corrosion beneath paint. The reflected and back-scattered light from different species and locations in matter had different degrees of polarization.

Based on the spectral and polarization properties of the light scattered, we are going to assemble a near infrared (NIR) computerized imaging unit. The prototype unit will be used to detect cracks or corrosion beneath a painted metallic surface over a small area of 5 X 5 cm². The most important advantage of this technique will be its good resolution, low cost, and ability to detect corrosion/defects of metallic surface beneath a
paint layer. I believe this technique will be a promising one for detecting cracks and/or corrosion beneath paint such as those cracks in airplanes.

**Research Plan:**

Two versions will be designed and tested, point and area scanning approaches. Backscattering geometry will be used to image the surface and subsurface structures in corroded metals covered with a paint coating. A laser of wavelength near 1500 nm will be used in scanning the desired area. The beam will be focused onto the sample using the beam forming optics unit. The size that will be scanned or imaged is about 3 X 3 ft². In point scan unit, the backscattered signal from the sample will be collected and focused onto two photomultiplier tubes as shown in Fig.1. The first photomultiplier is to measure the parallel component intensity of the scattered light mostly from the surface of the painted corroded sample. The second photomultiplier is to measure the perpendicular component intensity of the scattered light resulted from the corroded sample, depolarized by the paint. In this approach the entire area will be mapped using video based system.

A computer-controlled phase lock-in amplifier will be used to detect and record the signal from the photomultiplier tubes. A stepping motor will be used in scanning the depth (z) -controlled by translational stage, and lateral (x,y) dimensions of the sample.
Fig. 1 a NIR Imaging unit.

Also a second unit using a CCD camera will be used in imaging, forward scattering imaging and backward scattering, cracks and corrosion beneath paint.
**Activities:**

The specific milestones of the research are shown in Table 1:

**Milestone Table**

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Task 1: Test sample model using NIR unit, Months 1-2:

(1) Testing model of corrosion beneath paint for different paint colors using the breadboard NIR CCD imaging instrument;

(2) Imaging model of corrosion beneath paint samples at different thickness to detect corrosion;

(3) Determine the best wavelengths for imaging and detecting corrosion beneath paint

Task 2: Design the second NIR scanning imaging unit, Months 3-5:

(1) Establish functional requirements and specification for the unit

(2) The unit will be connected to a programmed scanner for easier and faster detection as shown in Fig.1.

Task 3:

(1) Build the NIR Scanning Imaging unit, Months 6-8: A NIR CCD imaging instrument will be build which satisfy the design model and the best conditions.

Test 4: Test sample in the lab, Months 9-10

(1) Test model using the advanced second generation NPS instrument at CCNY lab.
(2) Resolution and depth will be checked.

(3) Test the advanced NPS unit on the field (for example detection of corrosion/dent beneath paint on cars).

(4) Improve the function and the software of the advanced second generation NIR unit.

**Task 5:** Optimize the unit and prepare final report, Months 11-12:

(1) Improve the unit (optically, software, etc) based on the experimental results on the field.

(2) Check the improved unit on the field again for the best results (size, resolution and depth)

(3) Write up a final report on the design and test results

**Budget Justification**

The requested funds will be used to (1) support optical scientists, software engineering, electronic engineering to carry out the proposed research work; (2) purchase necessary white light and laser sources, optical components, and electronic parts to assemble the advanced near infrared spectral polarization imaging instrument; and (3) maintain the imaging system and laboratory supplies.