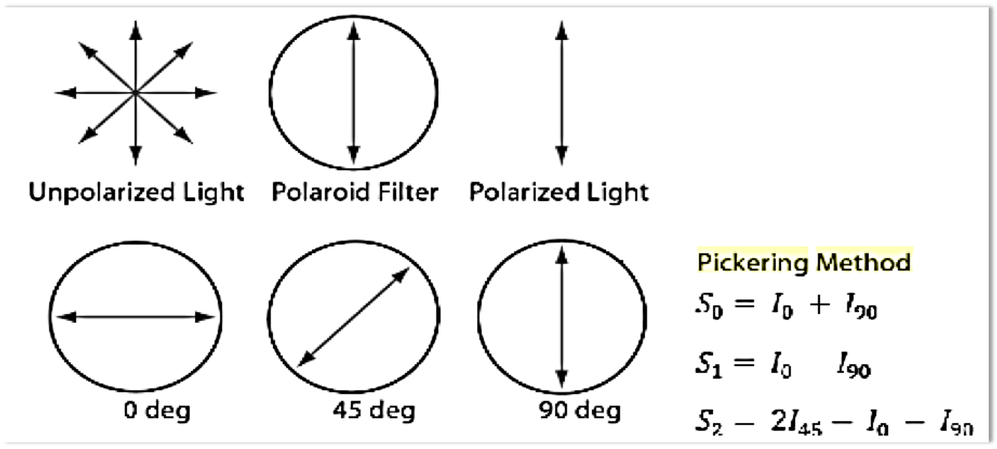
HACETTEPE UNIVERSITY
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
ELE 401-402 GRADUATION PROJECT

SYNTHETIC IMAGING SYSTEM

Alp DEMİREL, Sergen GÜLAL, Yalın GÜLSATAN
Supervisor: Dr. Yakup ÖZKAZANÇ

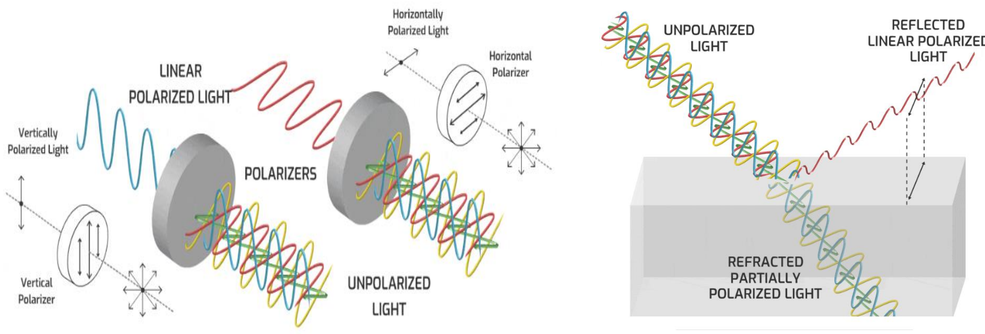
Project Description: In this project, 3 RGB (red, green, blue) cameras and polarized filters placed at different angles (0 °, 45 °, 90 °) in front of them are used to, obtain 3 different data based on the polarization feature, which is one of the three properties of light. Using 3 different data from equations known as ''Stokes Parameters'' AoP (Angle of Polarization) and DoLP (Degree of Linear Polarization) are obtained which are properties of light.



By using the polarization feature of light, data from three different parameters determined by Pickering Method as S0, S1, S2 are processed and AoP and DoLP images are obtained.

What is Polarized Light?

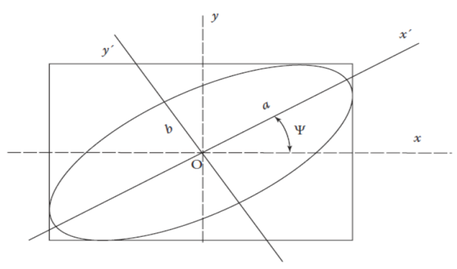
Light is a transverse electromagnetic wave. As it propagates, it oscillates perpendicular to the direction of propagation. Most light sources emit unpolarized light, with all the waves oscillating at random angles. When light is aligned so that most waves oscillate at a common angle, it is said to be polarized. Circular polarization is also possible, though it is beyond the scope of this guide.



Stokes Parameters

1. The total intensity of the light (polarized + unpolarized) S0
2. The intensity of linear horizontal or vertical polarization S1
3. The intensity of linear +45° or -45° polarization S2
4. The intensity of right or left circular polarization S3

$$S_0 = E_x^2 + E_y^2$$
$$S_1 = E_x^2 - E_y^2$$
$$S_2 = 2E_xE_ycos\emptyset$$
$$S_3 = 2E_xE_ysin\emptyset$$



$S_0^2 = S_1^2+S_2^2+S_3^2$ *completely polarized light* (linear, circular, and elliptical polarized light)
$S_0^2 > S_1^2+S_2^2+S_3^2$ partial and unpolarized light

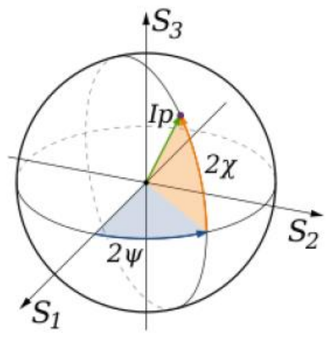
$$I = S_0$$
$$p = \frac{\sqrt{S_1^2 + S_2^2 + S_3^2}}{S_0}$$
$$2\psi = \text{atan}\frac{S_2}{S_1}$$
$$2\chi = \text{atan}\frac{S_3}{\sqrt{S_1^2 + S_2^2}}$$

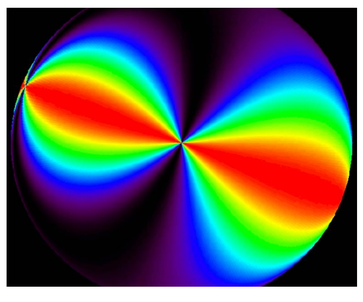
Where,

ψ is Angle of Polariation(AoP)

p is Degree of Polarization(DoP)

$$\text{Degree of Linear Polarization} = \frac{\sqrt{s_1^2 + s_2^2}}{s_0}$$

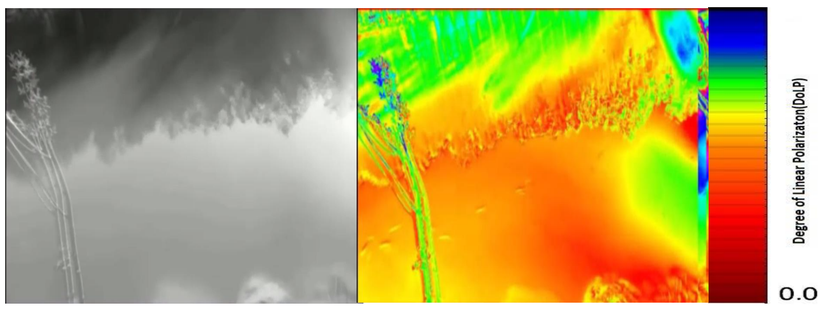




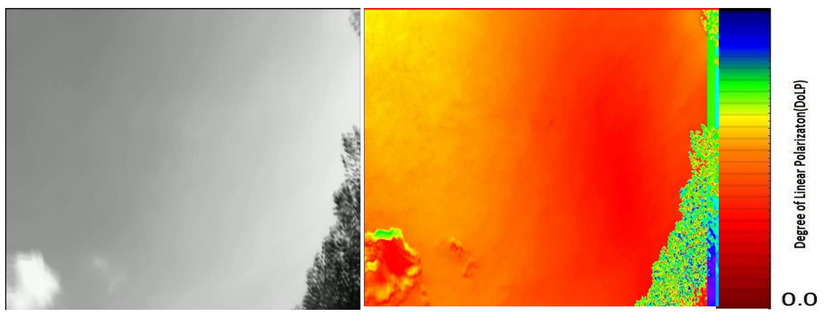
Rayleigh Sky Model

Explains the observed polarized model of sky structure seen in daytime. Each color in the model refers to a different polarization angle. The similarity of this model in reality is obtained in our test images.

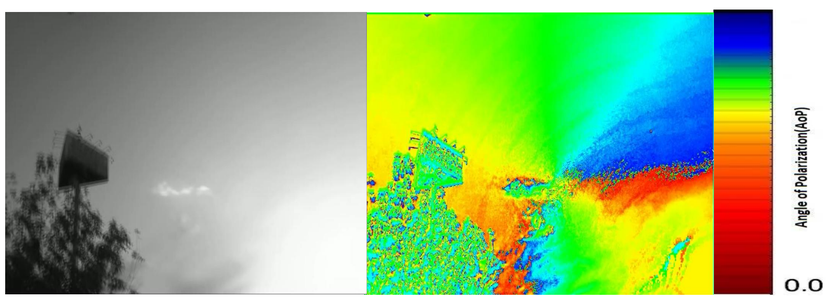
Test Images



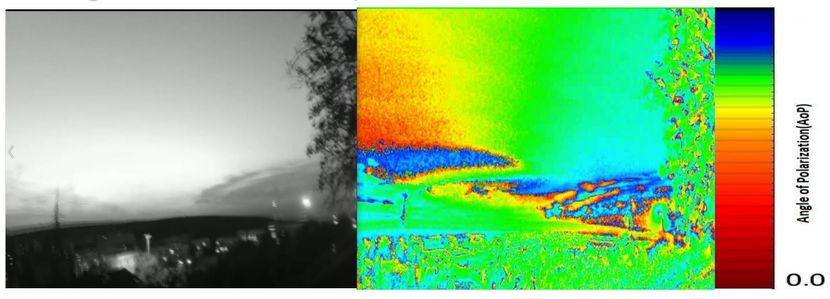
While fish cannot be seen very clearly on the surface of the water in the normal image (left), the fish in the image taken on the DoLP parameter (on the right) can be clearly distinguished. Where the degree of polarization is high, it is observed that the color scale approaches the high degree color.



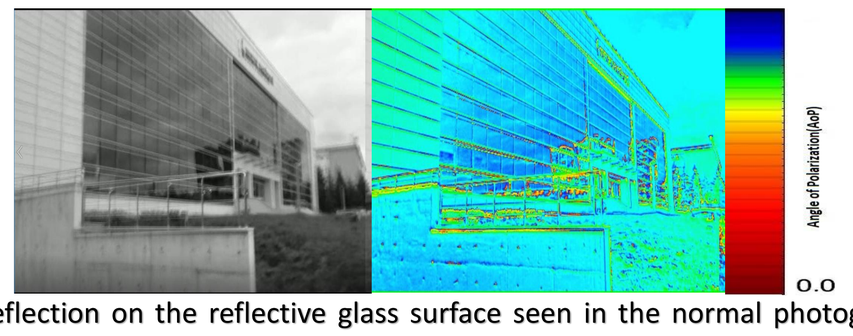
If the above images are viewed from the normal (left) image to DoLP (right) image; the red region in the DoLP image is where the sun's rays intensify. The color scale increases to yellow as the degree of polarization increases as it moves away from the sun.



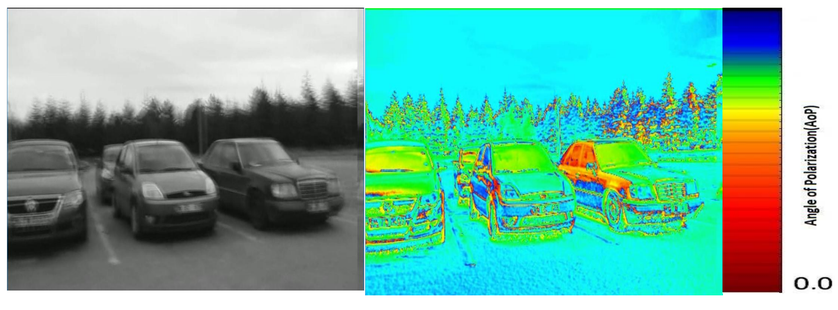
In the image taken with the AoP parameter, due to the varying degrees of polarization of the rays, a similar shape can be observed to the Rayleigh Sky Model. This figure can also be compared to wind rose.



It was determined that the Rayleigh Sky Model could still be observed in these images taken after sunset. In addition, this figure is gradually flattening and disappearing.



The reflection on the reflective glass surface seen in the normal photograph (left) can be clearly distinguished by the AoP parameter in the image taken (right). At the same time, indentations in the front wall can be detected in the AoP image.



Looking at the view of the three cars in normal view with the AoP parameter (right); reflections of car windows due to the light coming from different angles it is noticeable that it is located on different color scales.