Pattern Recognition for Passive Polarimetric Data Using Nonparametric Classifiers
V. Thilak, J. Saini, D. G. Voelz, and C. D. Creusere

ABSTRACT
Passive polarization based imaging is a useful tool in computer vision and pattern recognition. A passive polarization imaging system forms a polarimetric image from the reflection of ambient light that contains useful information for computer vision tasks such as object detection (classification) and recognition. Applications of polarization based pattern recognition include material classification and automatic shape recognition. In this paper, we present two target detection algorithms for images captured by a passive polarimetric imaging system. The proposed detection algorithms are based on Bayesian decision theory. In these approaches, an object can belong to one of any given number classes and classification involves making decisions that minimize the average probability of making incorrect decisions. This minimum is achieved by assigning an object to the class that maximizes the a posteriori probability. Computing a posteriori probabilities requires estimates of class conditional probability density functions (likelihoods) and prior probabilities. A Probabilistic neural network (PNN), which is a nonparametric method that can compute Bayes optimal boundaries, and a K-nearest neighbor (KNN) classifier, is used for density estimation and classification. The proposed algorithms are applied to polarimetric image data gathered in the laboratory with a liquid crystal-based system. The experimental results validate the effectiveness of the above algorithms for target detection from polarimetric data.


Use of Polarization to Improve Signal to Clutter Ratio in an Outdoor Active Imaging System
P. F. Fontoura, M. K. Giles, and D. D. Padilla

ABSTRACT
This paper describes the methodology and presents the results of the design of a polarization-sensitive system used to increase the signal-to-clutter ratio in a robust outdoor structured lighting sensor that uses standard CCD camera technology. This lighting sensor is intended to be used on an autonomous vehicle, looking down to the ground and horizontal to obstacles in an 8 foot range. The kinds of surfaces to be imaged are natural and man-made, such as asphalt, concrete, dirt and grass. The main problem for an outdoor eye-safe laser imaging system is that the reflected energy from background clutter tends to be brighter than the reflected laser energy. A narrow-band optical filter does not reduce significantly the background clutter in bright sunlight, and problems also occur when the surface is highly absorptive, like asphalt. Therefore, most of applications are limited to indoor and controlled outdoor conditions. A series of measurements was made for each of the materials studied in order to find the best configuration for the polarizing system and also to find out the potential improvement in the signal-to-clutter ratio (STC). This process was divided into three parts: characterization of the reflected sunlight, characterization of the reflected laser light, and measurement of the improvement in the STC. The results show that by using polarization properties it is possible to design an optical system that is able to increase the signal-to-clutter ratio from approximately 30% to 100% in the imaging system, depending on the kind of surface and on the incidence angle of the sunlight. The technique was also analyzed for indoor use, with the background clutter being the room illumination. For this specific case, polarization did not improve the signal-to-clutter ratio.


Jones Matrix Model with Field Angle Effects for a Liquid Crystal Variable Retarder
X. Xiao and D. Voelz

ABSTRACT
An analytic mathematical model is developed for a Liquid Crystal Variable Retarder (LCVR) based on an extended Jones matrix representation. The model is used to determine the polarimetric response of the LCVR to rays of non-normal incidence. The model shows reasonable agreement with laboratory measurements of a LCVR for both linear and circular input polarizations at arbitrary incident angles. The model is also applied to a two-LCVR imaging polarimeter system that is capable of measuring the full Stokes parameters of a scene. It is shown that the LCVR response can have a significant effect on the recovered Stokes values for non-normal incidence, which is important for determining the polarimetric performance of such a system over an extended field-of-view.


Real-Time Polarization Measurement with FPGA Processing
A. Jayaseelan and D. Voelz

ABSTRACT
Existing polarization imaging cameras typically use a set of sequential measurements and involve some physical motion of optical elements or changes in a liquid crystal element. In this paper, we present a spatially parallel polarization measurement approach that is designed to give measurements in real time. The idea is to use a group of 2 x 2 detectors where each detector responds to a
different polarization. The signals from the detectors are sent to a digital processing unit where polarization parameters of interest are calculated in real-time. A laboratory prototype is presented that uses a quad-cell photodiode detector array with different polarizing elements placed over each detector. The signals from the detector elements are sent through amplifiers to A/D converters and then into a Field Programmable Gate Array (FPGA). This high-performance processing unit calculates various parameters such as degree of polarization and partial polarization. As the processing unit is fast, real-time operation is possible. Arrays of 2 x 2 groups will ultimately be required for image sensing.


Field-of-View Characteristics of a Liquid Crystal Variable Retarder
X. Xiao, D. Voelz, and H. Sugiura

ABSTRACT
We examine the effect of incident angle on the Liquid Crystal Variable Retarder (LCVR) and develop a Mueller matrix formulation for the LCVR that is a function of incident angle and applied voltage. By comparing the model with laboratory measurements for both linear and circular input polarization, we show that the mathematical model provides a credible representation of a real LCVR. The model can be used to determine the field angle effects of LCVRs in complex optical polarization systems.