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Title: "Sensing Passive Thermal Objects in Outdoor Scenes for Autonomous Robots"

Abstract:

Autonomous robots require the ability to make decisions such as "go through the hedges" or "go around the brick wall." We have designed and implemented a physics-based adaptive Bayesian pattern classification model that uses an infrared imaging system to automatically sense passive thermal objects in outdoor environments for mobile robots. In the context of this research, passive thermal objects are defined as objects that are not a source for their own emission of thermal energy, and so exclude people, animals, vehicles, etc. The resulting classification model complements an autonomous robot's situational awareness by providing the ability to characterize smaller structures commonly found in the immediate operational environment. A thermal infrared imaging modality mounted on a small mobile robot is a favorable choice for receiving enough detailed information to automatically interpret objects at close ranges while unobtrusively traveling alongside pedestrians. The classification of indoor objects and heat generating objects in thermal scenes is a solved problem. A missing and essential piece in the literature has been research involving the automatic characterization of passive thermal objects in outdoor environments using an infrared imaging modality for mobile robots. Seeking to classify passive thermal objects in outdoor environments using an infrared imaging system is a complex problem due to the variation of radiance emitted from the objects as a result of the diurnal cycle of solar energy. The model that we present will allow robots to "see beyond vision" to autonomously assess the physical nature of the surrounding structures for making decisions without the need for an interpretation by humans.

Our approach is an application of Bayesian statistical pattern classification where learning involves labeled classes of data (supervised classification), assumes no formal structure regarding the density of the data in the classes (nonparametric density estimation), and makes direct use of prior knowledge regarding an object class's existence in a robot's immediate area of operation when making decisions regarding class assignments for unknown objects. We have used a mobile robot to systematically capture thermal infrared imagery for two categories of passive thermal objects (extended and compact) in several different geographic locations. The extended objects extend laterally beyond the thermal camera's field of view, such as brick walls, hedges, picket fences, and wood walls. The compact objects are completely within the thermal camera's lateral field of view, such as steel poles and trees. We used these large representative data sets to explore the behavior of thermal-physical features generated from the signals emitted by the classes of objects and design our Adaptive Bayesian Classification Model. We demonstrate that our novel classification model not only displays exceptional

performance in characterizing passive thermal objects in outdoor scenes but it also outperforms the traditional KNN and Parzen classifiers.

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