Chapter 1
Optoelectronic Devices Fusion in Machine Vision Applications

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ABSTRACT

This chapter presents the application of optoelectronic devices fusion as the base for those systems with non-linear behavior supported by artificial intelligence techniques, which require the use of information from various sensors for pattern recognition to produce an enhanced output. It also included a deep survey to define the state of the art in industrial applications following this tendency to identify and recognize the most used optoelectronic sensors, interconnectivity, raw data collection, data processing and interpretation, data fusion, intelligent decision algorithms, software and hardware instrumentation and control. Finally, it exemplifies how these technologies implemented in the industry can also be useful for other kinds of sector applications.

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INTRODUCTION

With the continual technology grow due to innovations in sensors, devices, and systems, especially those based in a machine vision approach and also enhanced by the internet of things, and in consequence considered smart sensors, devices or systems, the industrial sector is in a revolution. Also, quotidian and modern human life habits have drastically changed with the incorporation of those devices and interconnectivity. Machine vision is supported and enhanced by optoelectronic devices, traditional signal, and image processing methods, as well as by novelty artificial intelligence algorithms, and the fusion of all these. The output from a machine vision system is information about the content of the optoelectronic signal, it is the process whereby a machine, usually a digital computer and/or electronic hardware automatically processes an optoelectronic signal and reports what it means. Machine vision methods to provide spatial coordinates measurement has developed in a wide range of technologies for multiples fields of applications such as robot navigation, medical scanning, structural health monitoring and industrial process. Each technology has specified properties that could be categorized as an advantage and disadvantage according to its utility to the application purpose. With these technologies implementations, most of the industrial processes can be automated and optimized, resulting in recognition, popularity and high revenue for the industrial trademark, and in a continuous lifestyle evolution.

The present chapter surged in the research continuity of a 3D Vision System for a mobile robot navigation application (Basaca-Preciado, 2014), a 3D medical laser scanner (Rodriguez-Quiñonez J. C., 2014), a structural and environmental health monitoring system (Rivera-Castillo, 2017), a measurement of vegetation vitality system (Lindner L. S.-L.-B.-F.-Q.-P., 2017), and an industrial measurement system (Lindner, 2016). With the objective of increasing the accuracy of the systems, digital and analog processing signals methodologies have been developed in order to find the energetic center of the optoelectronic signal handled by these systems. Into the task of systems overall robustness, its measurement data has been submitted to statistical analysis, finding a non-linear behavior of the systems, leading to the need of artificial intelligence application such as neuronal network (NN) (Rodriguez-Quiñonez J. a.-B.-L.-F.-P., 2014), k-Nearest Neighbor (k-NN) (Real-Moreno, 2018) and support vector machine regression (SVMR) (Flores-Fuentes W. a.-L.-N.-C.-B.-Q., 2014), in a modern approach to the prediction of the non-linear measurement error of the systems to compensate it. In the process of obtaining enough information from a measurement system to extract from it a model to predict its measurement error. It has been done a search of attributes to build the training dataset and test dataset. It has been found that pattern recognition can be enhanced by the sensor fusion and redundancy theory. This theory refers to the synergistic use of information from various sensors to achieve the task required by the system. Input data (attributes) are combined, fused and grouped for proper quality and integrity of the decisions to be taken by the artificial intelligent algorithm. Besides, the benefits can be extracted from the redundant data, the reduction of uncertainty and the increasing of precision reliability. For these reasons, the photodiodes and charge-coupled devices (CCD) are fusion in the task of robust systems building for machine vision by Spatial Coordinates Measurement (Weckenmann, 2009), (Elfes, 1992), (ZHANG, 2008), (Shih, 2015). The specific properties of both, their advantages and limitations have been considered, since, the photodiode is the sensor who gives place to the laser-scanning and the CCD is the sensor which gives place to the close-range photogrammetry. The energetic center of the laser optoelectronic signals from the photodiode and the energetic center of the image signal from the CCD sensor are detected to combine these sensors outputs, and to exploit their natural synergy, experimental results are presented to demonstrate the increase of systems accuracy.

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