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Guest Editorial

Special issue on computer vision beyond the visible spectrum

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Traditionally, the majority of the computer vision community has been involved implicitly or explicitly with the development of algorithms associated with sensors that operate in the visible band of the electromagnetic spectrum. Imaging sensors from other bands of the spectrum are used only in special applications (e.g., medicine, military). There are a number of reasons for this situation: low cost and availability of visible-band sensors, strong links between the computer vision research and the human vision research, and lack of consideration of the potential advantages offered by other bands of the spectrum.

Sensors in the nonvisible bands are being increasingly used for practical applications. Recently, the cost of near- and mid-infrared sensors has dropped dramatically. New imaging sensors that operate in the millimeter wave (MMW) band of the spectrum have started to appear in a growing number of applications. Image-sensing devices that were once suitable only for military and remote-sensing applications now find their way into more common areas like transportation and security vision-based systems. Application of these new sensing modalities into a wide variety of computer vision systems necessitates either the adaptation of methods and algorithms originally developed for the visible sensors or the development of entirely new methods and systems.

This special issue consists of seven papers that represent the sample of current research in computer vision beyond the visible spectrum (CVBVS). The papers were chosen from the papers presented at the first IEEE Workshop on Computer Vision Beyond the Visible Spectrum (CVBVS 1999) held at Fort Collins, Colorado, USA. The selected workshop papers were improved and extended to become appropriate for journal publication. The editors and the panel of reviewers based their selection on technical merit and broad representation of the technologies. The papers present research for both military and civilian applications. They also present research efforts from both academia and industry. Finally, they present methods and algorithms developed for various bands of the electromagnetic spectrum ranging, from the near-infrared to the short- and long-wave infrared to laser radar and to synthetic aperture radar (SAR) imaging systems.

The first paper by Strehl and Aggarwal addresses an important military application problem in the thermal infrared band of the electromagnetic spectrum. Aircraft, helicopters and unmanned drones carry forward-looking infrared (FLIR) imagers for automatic (or aided) target recognition (ATR) on the ground. The paper proposes a motion-based object detection system for FLIR images sequence. The paper adapts a well-known robust techniques from the visible to the FLIR domain. The method removes ego-motion effects through a multi-scale affine image registration process. Then, it detects areas of residual motion using a Bayes classifier. The iterative nature of the image registration process assures a scalable algorithm complexity.

The second paper by Castellano et al. addresses the same problem as the first paper, but using an entirely different approach. The authors propose a modified complex discrete-wavelet transform (CDWT) optical-flow algorithm to detect moving targets in FLIR image sequences. The modification they introduce performs an explicit regularization of the motion field. The result is robust detection of moving targets, even in very noisy FLIR sequences. The resilience of the method, however, is obtained at a computational cost.

The third paper by Bhanu et al. also addresses the ATR problem in the military context, but for a different sensor modality - the synthetic aperture radar. Current SAR ATR systems are generally multi-level systems that process image data sequentially at low, intermediate, and high levels and without any feedback between levels. This paper proposes to close the loop with the introduction of a reinforcement learning-based mechanism that learns the parameters of the system. The feedback mechanism is based on minimizing the difference between the actual performance of recognition and the desired performance specified by the user in terms of probability of correct identification and probability of false alarm. Results are presented on a variety of SAR data dealing with target configuration variants, target articulations and sensor depression angle variations.

The area of military applications concludes with the fourth paper by Khabou et al. The paper introduces morphological shared-weight neural networks (MSNNs) as a powerful generic detection method that can be applied to FLIR, SAR, and laser radar ATRs. MSNN elegantly com-

bine the feature extraction capability of mathematical morphology with the function-mapping capability of neural networks. The paper provides experimental results from laser radar image sequences.

The paper by Scribner et al. deals with the issue of sensor fusion in the infrared (IR) spectrum, which can have applicability both in the civilian and military domains. The primary limitation of thermal infrared imaging systems is that contrasts between objects and backgrounds are frequently minimal, making object detection in infrared imagery problematic. The situation can be improved through the use of multiband imagery. Nevertheless, this leaves open the question of displaying the multi-band information in an effective manner. The paper proposes the use of color fusion (IR or combined IR and visible) as a means of displaying multi-band infrared imagery. This method can be used for improving the viewer's scene comprehension and emphasizing relevant information. Several examples are presented.

The paper by Pavlidis et al. addresses a difficult problem in the transportation domain. It proposes a method for reliably detecting passengers in vehicles on the freeway. The method is based on the fusion of two different bands of the near-infrared spectrum. In one band, the human skin has high reflectivity, while in the other, very low reflectivity.

At the same time, all the other objects in a typical freeway scene appear to have almost constant reflectivity in both bands. Based on this phenomenology, the authors have developed a weighted subtraction scheme that leaves only the passenger faces on the image. By eliminating all the clutter, the method increases substantially the reliability of further computer vision processing.

Finally, the paper by Jimenez et al. addresses another civilian application problem, this time in the agricultural domain. The paper presents an automated fruit harvesting method based on range and reflectance images generated by a laser sensor. The strong point of the paper is the fusion of both range and reflectance information to generate four characteristic primitives designating the presence of spherical objects which are likely to be fruit.

We hope that this collection of papers will serve as a point of reference for the computer vision community and motivate further interest and research for applications dealing with non-visible sensors, particularly in the civilian domain.

In closing, we would like to thank the reviewers for their careful and prompt reviews.