

Image Fusion Techniques with Multiple-Sensors

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INTRODUCTION

In the human perception to the outside real world, many organs play important roles. They capture information from the real world and send them to the brain for interpreting and understanding the situation. This is reflected also in the current construction of intelligent robots, in which many sensors for sense of vision, sense of hearing, sense of taste, sense of smell, sense of touch, sense of pain, sense of heat, sense of force, sense of slide, sense of approach, etc. (Luo & Jiang, 2002), are built and used. All these sensors provide different profile information of the real world in same environment. To use suitable techniques for assorting with various sensors and combining their obtained information, the theories and methods of information fusion with multiple-sensors are required.

Information fusion with multiple-sensors is a basic ability of human beings, and is also a must for contemporary machinery. In many cases, the information provided by a single sensor could be incomplete, un-accurate, vague, with many uncertainty. Sometimes, information obtained by different sensors can even be contradictory. Human beings have the ability to suitably combine the information obtained by different organs and then make estimation and decision for environment and events. Using computer to perform multi-sensor information fusion can be considered as a simulation of the function of human brain for treating complex problems.

Information fusion with multiple-sensors consists of operating on the acquired data come from various sensors, using available technology to treat the condensed information and obtaining more comprehensive, accurate, and robust results than that obtained from single sensor. Fusion can be defined as the process of combined treating of data acquired from multiple

sensors, as well as assorting, optimizing and conforming of these data to increase the ability of extracting information and improving the decision capability. Fusion can extend the information coverage for space and time, reducing the fuzziness, increasing the reliability of making decision, and the robustness of systems.

Image fusion with multiple-sensors is a particular type of information fusion with multiple-sensors, which takes images as operating objects. As an image is worth a thousand words, and around 75% of the information obtained by human beings from outside world was via vision, image fusion with multiple-sensors attracted a lot of attention recently in information society. This article will introduce the principle, main step of image fusion, discuss some typical fusion methods and their combinations, and point out several potential future development directions.

BACKGROUND

There are many modalities for capture image and video, which use various sensors and techniques (Brakenhoff, et al., 1979; Committee, 1996; Bertero & Boccacci, 1998), such as visible light sensor (e.g., CCD, CMOS), infrared sensor, depth sensor (e.g., Kinect), con-focal scanning light microscopy (CSLM), a variety of computer tomography techniques (CT, ECT, SPECT), magnetic resonance imaging (MRI), synthesis aperture radar (SAR), millimeter wave radar (MMWR), etc.

Main Steps of Image Fusion

There are three main steps involved in image fusion with multiple-sensors, in which various image techniques can be used (Zhang, 2012).

1. Image Pre-Processing

Image fusion with multiple-sensors is carried out among images captured with different sizes, different resolutions, and different dynamic ranges of gray levels or colors. The pre-processing of images includes image normalization (gray level equipoise, re-sampling, and interpolation), image filtering, color enhancement, edge sharpening, etc. Image normalization is to normalize the size, resolution and dynamic range parameters. Image filtering is to high pass filter the higher resolution image to obtain high frequency texture information, to keep it in fusion with lower resolution image. Image color enhancement is to increase the color contrast in lower resolution image, to reflect the spectrum information into the fused image. Edge sharpening is performed on high-resolution image for making the boundary clear and reducing noise, thus it fuses the space information from high-resolution image to low resolution image.

2. Image Registration

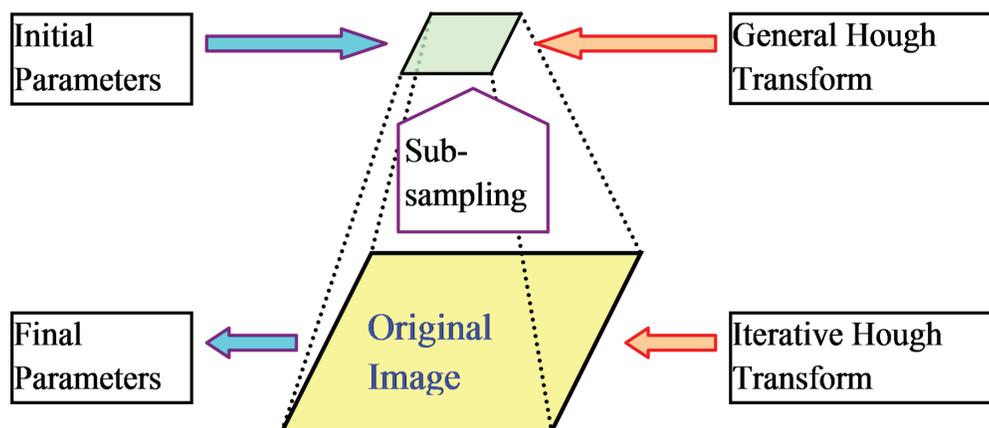
In image fusion with multiple-sensors, information from different images for the same spatial-temporal locations should be combined. This has a high requirement for accurate registration. Such a process, in a more general sense, is a special case of image matching, which has many existing techniques (Kropatsch & Bischof, 2001; Shapiro & Stockman, 2001; Buckley & Lewinter, 2003; Zhang, 2012). It is evident that if the registration error is higher than one pixel/voxel, then the fused results will show superposition effect and the visual quality of image will be greatly reduced.

Image registration can be classified as relative registration and absolute registration. The relative registration takes one image from many images of the same category as a reference image; other images will be aligned relatively to this reference image. Absolute registration takes the spatial-temporal coordinate system as the reference system; images to be fused will be aligned relative to this system.

From a technique point of view, image registration can be classified also as region-based registration and feature-based registration. Control point (corresponding points in both images to be registered) is a typical feature used in feature-based registration. Once the correspondence between control points was determined, the registration process can be carried out with determined parameters. The general Hough transform (GHT) is a commonly used registration technique. It can be considered as an evidence accumulation method. The global search space depends on the scale and rotation parameters, and can be very huge. To reduce the complexity of GHT, iterative Hough transform (IHT) can be used. However, IHT is influenced by the initial parameters and the range of parameter values, and often converged to local maximum. By using Hough transform in a multi-resolution decomposition environment, as shown in Figure 1, the robustness of GHT and computation efficiency of MIHT can be combined (Li & Zhang, 2005a).

In multi-resolution decomposition-based techniques, few control points are used in low-resolution layer in which GHT is used to obtain accurately the initial values of transform parameters. While in high resolution, IHT is used to accelerate the process.

Figure 1. Framework for image registration using control point-based multi-scale Hough transform



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