Analysis of Multi-sensor Image Fusion

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Abstract: As a new discipline, information fusion technology has achieved rapid development in recent years. It has been widely used in military and civil affairs and has had a major impact on human production and lifestyle. The three fusion levels of multi-sensor image fusion and the typical fusion methods at each fusion level are mainly introduced. The single fusion method has its own advantages and disadvantages. To overcome the problems of the single fusion method, a single fusion method can be combined to compare the effects of the fusion image from gray standard deviation, average gray level gradient, and entropy. It can be found that combining two single fusion methods can achieve complementary advantages, obtain better fusion effects, and analyze and summarize a variety of different fusion methods, which can provide a certain reference for the application of fusion algorithms.

1. Introduction

The development of disciplines such as optics, electronics, mathematics, photography, and computer technology, the improvement of the performance of processors, memories, and display devices, and the continuous decline in prices have led to the rapid development of digital image processing [1]. The application needs of military, medical, natural resource exploration, marine resource management, environment and land use management, topography and geomorphology analysis, and biology have strongly stimulated the development of image processing and image fusion technologies. Medically, image fusion technology is used to diagnose and develop surgical plans. Business and intelligence departments use image fusion technology to restore and convert old photographs and video tapes. With the development of remote sensing technology, more and more methods are available for acquiring remote sensing data. The image data obtained by various sensors form image pyramids in the same area. The image fusion technology realizes complementary advantages of multi-source data, and provides for improving the use efficiency of these data. An effective way. The satellite-based remote sensing is used for mapping, multispectral, hyperspectral analysis, data visualization, and digital earth construction. Image fusion is an indispensable technique. Militaryally, image fusion can be used for battlefield awareness and monitoring.

2. Sensor Combination

The combination of millimeter-wave (M MW) radar, LADAR and infrared sensors provides active and passive working methods. In the combination of LADAR and forward-looking infrared (FLIR), FLIR is used to search for and detect possible targets, combining FLIR and LADAR information for identification. The M MW radar has a high anti-decay ability. The US Army plans to select MMW radars and thermal imaging cameras as the breakthrough for image fusion in the next generation of tanks and is being studied by Hughes. The fusion of SAR and infrared images aims to make full use of the characteristics of SAR imagery that can be acquired all-weather and the rich spectral features of infrared images. The fusion image with high spatial resolution and spectral resolution is obtained on remote sensing telemetry applications. There is a large temperature gradient in the target or a large thermal contrast between the background and the target. The low-visibility target is easily visible in the infrared image. Compared with the thermal image, the visible image can provide more target details. If FLIR and TV images are combined, the resulting fused image retains important details characterized by a high local brightness contrast. In order to improve the night battle capabilities of the US military, Texas Instruments has developed weapons and equipment with infrared thermal images and low-light image fusion capabilities. The United States also studied an adaptive data fusion experiment bed based on visible light and infrared images, simulated the battlefield environment using image fusion methods, and conducted some experiments in the field. The fusion process can mutually treat synthetic aperture radar (SAR) and use two antennas to improve the matching of observation scenes, and obtain fusion of different frequencies or polarization images of the same sensor. This requires the correction of electromagnetic measurements and multi-polarization, multi-frequency image fusion, image mutual alignment, and the like. With the fusion of different resolution SAR images, a fused image with lower noise than high resolution images can be obtained. Multi-frequency, multi-polarization, multi-resolution SAR image fusion can be used for image fusion using neural network, wavelet transform and multi-scale Kalman filtering.

The clinical application of various medical imaging methods has made great progress in medical diagnosis and treatment techniques. At the same time, complementary information from various imaging technologies has become a powerful weapon for clinical diagnosis and treatment and biomedical research. Such as: X-ray tomography (C T), positron emission tomography (PET), magnetic resonance (M RI), single photon emission tomography (SPET), ultrasound imaging (US), microscopic imaging (MI) and so on. Different modal images provide complementary information that does not cover each other. For example: CT provides bone information, M RI provides soft tissue, blood vessels and other information. Choose CT properties where there are bones, select M RI properties where there are other soft tissues, and fuse the information for the planning of the surgery. In the future, the combination of digital visualization based on image fusion and virtual reality technology is expected to create a virtual environment to help doctors formulate the most effective and safe surgical plan.

3. Classification of Image Fusion

Image data fusion is divided into: pixel layer fusion, feature layer fusion and symbol layer fusion. The pixel layer image fusion is to fuse the original image to form a new image. Pixel-level image fusion can be used to increase the information content of each pixel in the image, providing more characteristic information for the next image processing, and it can more easily identify potential targets. If the images participating in the fusion have different resolutions, they need to be mapped in the corresponding areas of the image. Pixel-level image fusion generally requires spatially precise alignment of the sensor, which is usually achieved by placing multiple sensors on the same platform [1]. The pixel layer image fusion method is a low-level fusion that retains as much information as possible and has a high accuracy. Feature-level image fusion is a method that extracts the likelihood of the main features of each image and then combines the features. Feature-level data fusion requires the semantics of some data processing so that the target original features can be obtained, and feature-level data fusion is often associated with the target algorithm. Mapping a semantic meaning of a certain class to some space and/or time period of the sensor data, establishing "original" features, and establishing "synthetic" features by combining image features. Typical features extracted from the image and used for fusion include: borders and similar brightness or depth regions. Typical image feature extraction includes: boundary extraction, same density or same depth region representation. When multiple image sensors report similar features at the same location, the likelihood of actual appearance of the features can be increased and the accuracy of the measurement features can be improved. Features that do not receive such reports can be considered as false features and deleted. The fusion can eliminate false features to improve feature measurement accuracy (eg, determine the pose of an object), establish synthetic features, and improve related performance (eg, improve target recognition capabilities). The features established after the fusion can be the synthesis of each component feature, or it can be a completely new feature composed of the feature attributes of each component. The geometrical form, orientation, location, and time content of a feature are the most important aspects of the feature that need to be represented. These features can be aligned and merged with other features. The geometric transformation of the features available at the time of fusion matches it with other features or environment models. In some cases, a feature can be geometrically transformed, such as translation and rotation in the image plane. The sensor alignment requirements of the feature layer fusion are not as strict as the signal layer and the pixel layer, so the image sensor can be distributed on different platforms. Symbol-level image fusion is the process of logical reasoning or statistical reasoning of information from multiple images. If the sensor signal representation varies widely or involves different areas of the image, symbol-level fusion may be the only way to fuse multiple image information. The symbol used for the fusion may be information originating from sensors in the system, or symbols from environmental models or prior information of the system. The symbols derived from the sensor information represent decisions that have been made about a certain aspect of the environment, and are usually based on matching the features derived from the sensor information with the model to reason. Fusion at the symbol level generally does not explicitly consider sensor alignment because the spatial and temporal content of the sensor information that is the basis of the symbol has been explicitly taken into account when the symbol is formed. If the symbols participating in the fusion are not aligned, the spatial and temporal properties can be associated with the symbols for their alignment. In logical reasoning, each symbol participating in the fusion represents an item in a logical expression, and the uncertainty measure represents the true value of these items [2]. In statistical inference, each symbol that participates in the fusion is represented by a conditional probability expression, while the indefiniteness metric represents the probability metric related to the expression. The symbol layer fusion uses the increase of symbol truth or probability value established by inference results to represent the improvement of symbol layer fusion quality. The degree of improvement of the system performance by symbol layer fusion is generally reflected in the fact that the fused symbol has a greater probability or higher degree of truth.

4. Structure Model of Image Fusion

The process of image fusion can generally be summarized as: 1) image preprocessing, such as removing noise, image alignment, etc.; 2) determining the image fusion algorithm; 3) extracting features, identification, image understanding, and the like. Adding the information of image fusion effect evaluation to the selection of fusion rules and the selection of parameters can make full use of the information provided by the information source, and will get better results than the open-loop image fusion process.

Evidence reasoning or D-S (Dempster-Shafer) theory. Using the information obtained by the sensor as evidence, the basic trusted number, credibility function, and plausibility function of each sensor are calculated. Then, according to certain consolidation rules, the basic trusted number, credibility function, and plausibility of all sensors are calculated. The function finally follows a certain decision rule and chooses the goal with the maximum support [3]. The advantage of evidential reasoning is that it does not need to follow the principle of additivity and satisfy the semi-additive principle. The problem is that it should not be used to deal with conflicting evidence, because the normalization process in the combination rules can lead to contrary theories.

Pyramid fusion method. The main use of multi-scale expression, when the size of the image in the two orthogonal directions are double, the size of the image will be transformed by 4 times. At this time, the multi-scale expression will become a pyramid structure. The main process is to pyramid all the images that are involved in the fusion, and the decomposition results are merged according to certain rules on each layer. Finally, the original image is reconstructed by using the inverse process of pyramid generation. The disadvantage of this method is that it is easy to introduce noise during image fusion [4].

HSI (Hue-Saturation-Intensity) transformation fusion method. Image fusion operation with HSI transformation. The basic idea is to use the luminance component of the grayscale image with higher spatial resolution instead of the luminance component obtained after the HSI transformation.

Finally, the fusion image is obtained by inverse HSI transformation. The spatial resolution of the fusion image is greatly improved, but it can only be improved. At the same time, the three band images are fused, and there are serious spectral distortions.

PCA (Principal Component Analysis) transformation fusion method. Based on PCA (Principal Component Analysis), multiple bands of the image to be fused are selected for PCA transformation, and the single-band high-resolution image is subjected to grayscale stretching to make the first principal component image obtained by the transformation with the principal component gray. The mean and variance are consistent. Finally, a fused image is obtained through inverse PCA transformation. The advantage is that the high spatial resolution and high spectral resolution characteristics of the original image can be well preserved, and the sharpness of the fused image in terms of detail features is also higher. The disadvantage is that the input image analyzed must have two or more than two, And the useful information part of the first principal component of the image is lost, which ultimately affects the spectral resolution of the fused image.

5. Conclusion

For the fusion of sequence images, priority can be given to the weighted average method, which not only has a faster fusion speed but also can achieve better fusion effect. When the visible light image and the infrared image are combined, the pyramid fusion method is usually used to achieve a good fusion effect [5]. In recent years, wavelet transform plays an increasingly important role in image fusion with its good localization characteristics in time domain and frequency domain. By selecting proper fusion rules and fusion algorithms, it can obtain better fusion effects. Although multi-sensor image fusion technology has achieved significant results in many areas, there are still many problems, such as the need for further improvement in the fault-tolerance and robustness of multi-sensor systems. There are also many practical problems in the design of multi-sensor systems, and they have not yet formed a complete The theoretical system and effective generalized algorithms and models, etc., will become the focus of future research on multi-sensor image fusion.

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