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論 文 内 容 要 旨

Image inpainting is a technology that aims to recover missing information in a degraded image. There are many applications for image inpainting, such as recover the scratches in a photograph, repair the damaged regions of an image and remove the specified objects. Because of this, recently many image inpainting methods have been proposed. In the image inpainting methods, the damaged region of an source image is always named as the target region, and the undamaged region of the source image is always as known region. These methods are mainly divided into three categories: diffusion-based method, exemplar-based methods, and sparse representation-based methods. In the first category, it needs to smoothly propagate information from the known region into the target region. Although these diffusion-based inpainting methods perform well for filling the non-texture or relatively smaller missing region, some blur will be introduced in the texture or large missing region. In the second category, the image patch is seen as a unit, and the basic idea of these algorithms is finding the best match patch to copy directly to repair the target patch. However, the traditional exemplar-based methods which find the best match patch and then copy pixel values to restore the corrupted patch directly. It can cause unwanted information to the inpainting result. Moreover, searching the whole image to find the best match patch is time-consuming. Recently, with the development of the sparse representation, it has been introduced into image inpainting. Considering the problems of the diffusion-based inpainting methods and the exemplar-based methods, the first objective of this research is to propose an image

inpainting method based on sparse representation.

Images taken by digital cameras generally suffer from a certain level of degradation, e.g., due to the limited depth of field of lenses, which leads to that parts of imaging objects are focused while others are blurred. It is of great interest to develop multifocus image fusion (MFIF) techniques, which manage to detect the focused regions in multifocus images of the same scene and then integrate them to generate a composite image, in which all the objects of interest are in focus. According to domains in which the image information is combined, these techniques are roughly divided into transform domain methods and spatial domain methods. The former methods often require transforming the source images to different frequency coefficients, i.e., high-frequency and low-frequency coefficients. However, using the high-pass filters usually result in the ringing effects and “halo” around the major structures. Therefore, the second objective of this research is to propose a new multifocus image fusion method in the spatial domain.

With the development of various imaging devices, multimodal medical image fusion has become an important research topic to obtain accurate clinical information for better diagnosis by physicians. It is difficult to diagnose the patients' condition by just applying a single modality medical image. For example, the CT image can only show high-resolution information such as bone structures and implants with less distortion while MR image can only show normal and pathological soft tissues information such as flesh. Therefore, the technology of fusing different modality medical images into a single image has attracted many attentions. The third objective of this research is to propose a novel medical image fusion based on sparse representation.

Based on the motivations and objectives stated above, this thesis is devoted to study image inpainting and image fusion by sparse representation. The main results and contributions are concerned with the following four aspects:

1) A related dictionary is proposed based on comparing with summing the difference of R, G, B three channels between the target patch and candidate patches, and then a new image inpainting method is proposed based on the related dictionary.
2) A histogram dictionary is proposed based on comparing with maxing the difference of R, G, B three channels between the target patch and candidate patches, and then a new image inpainting method is proposed based on the histogram dictionary.
3) A new multifocus image fusion based on a structure-preserving filter is proposed. This structure-preserving filter aims to prevent smoothing across structure while still smoothing texture.
4) A new medical image fusion based on segment graph filter is proposed. This segment graph filter acts as a structure-preserving filter to decompose the source images into base images and detail images, and

The thesis is divided into four parts. The first part gives the background of image inpainting and image fusion, and the basic theory of sparse representation.

- In Chapter 1, the research background of image inpainting and image fusion, purpose, application and the construction of the thesis are described.
- In Chapter 2, some basic concepts are given for sparse representation and structure-preserving filter.

The second part presents the image inpainting methods based on related dictionary and histogram dictionary.

- In Chapter 3, a related dictionary and a histogram dictionary are proposed to extract more relevant patches from the candidate patches. In order to solve the problem caused by the existing dictionary, a new similarity comparison method using histogram is proposed. In this comparison method, the differences between candidate patches and target patches in R, G, B three channels are compared, and then sum the differences of three channels. In the last, sort the sum values to find the similar patches. Using the related dictionary, an image inpainting method is proposed. In view of the drawback of the related dictionary, an improved similarity comparison method using histogram is proposed and then a histogram dictionary is obtained. In the improved similarity comparison method, the differences between candidate patches and target patches in R, G, B three channels are sort by the max difference of R, G, B three channels. And then an image inpainting method based on histogram dictionary is proposed.

The third covers the multifocus image fusion and medical image fusion.

- In Chapter 4, a mutifocus image fusion based on a recursive filter is proposed. In the spatial domain method, the focus map is very important to the fusion result. The recursive filter can prevent smoothing across structures while still smoothing texture. In the proposed fusion, the recursive filter is used to refine the initial map and obtain the refinement map. It should be noted that because the traditional spatial method is always based on block, the “block artifacts” may be led into the fusion result. In order to avoid the “block artifacts”, we do not divide the source images into blocks in the proposed method. For medical image fusion, the single modality medical image cannot fully satisfy the doctors to diagnose the patient's condition. For example, the CT image can only show high-resolution information such as bone structures and implants with less distortion while MR image can only show normal and pathological soft tissues information such as flesh. In order to solve the problem, the technology of medical image fusion has been proposed. As the human visual system is sensitive to the edge information of source images, edge information should be integrated into the fused image as much as possible. The segment graph filter is used to preserve the structure information while smooth the texture information. And the source image can be decomposed into the base image and detail image by using the segment graph filter. Then the based image and detail image are applied the different fusion rule to fuse them. In the last, the fused based image and the fused detail image are combined to achieve a fusion result. Then, a medical image fusion method based on segment graph filter is proposed.

The third part gives the conclusions of the thesis.

- In Chapter 5, the main results of the thesis are summarized.

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論文審査結果要旨

本論文は、破損や古い画像の修復方法、複数の多焦点画像からボケのない鮮明な画像への融合方法について検討するものである。従来の画像修復方法は辞書用パッチと修復対象パッチの相関関係を考慮しておらず、修復結果に影響を及ぼす。また、従来の画像融合方法はブロック単位で違和感が残ることがある。そこで、本研究では辞書用パッチと修復パッチのヒストグラムの差を算出し、修復パッチと関係が近いパッチを選択して辞書に用いる画像修復方法と、画像ブロックの影響を避けるために、画像ブロックを利用しない画像融合方法を提案する。本論文は全 5 章から構成されている。

第 1 章は序論であり、画像修復と画像融合の背景、研究の目的について述べている。第 2 章では、スパース表現とエッジ情報を維持したフィルタと評価方法について述べている。第 3 章では画像修復方法について検討している。従来法では、画像中の修復対象パッチと同じ大きさの多数のパッチを辞書として用いることが一般的であるが、修復対象パッチと辞書用パッチとの相関関係は考慮されおらず、辞書用パッチに含まれる無関係な情報が修復結果に影響することがある。これに対し、提案手法では辞書用パッチと修復パッチのヒストグラムの差を算出し、修復パッチと関係が近いパッチを選択して辞書に用いる。実験により、画像修復精度が向上することを明らかにした。第 4 章では、焦点がずれた画像から 1 枚の合焦画像を生成する画像融合方法について検討している。従来法は、2 枚の画像をブロックに分割し、ブロック単位で焦点が合う領域を検出して 1 枚の画像を生成する手法が多い。そのため、ブロック単位で違和感のある領域が存在することがある。これに対し、本論文では画像ブロックを利用しない空間領域融合法を提案している。提案手法は原画像とローパスフィルタ適用画像との差分画像を取得し、回帰フィルタによりエッジ情報を維持しながら雑音を除去しつつ、焦点が合う領域を抽出できる。実験により、2 枚の画像から 1 枚の合焦画像を生成できることを明らかにした。また、画像融合の応用として医用画像の融合について検討し、MRI と CT の 2 枚画像からの 1 枚の融合画像を生成できることを明らかにした。第 5 章は結論であり、本研究をまとめ、関連研究課題について述べている。

以上、本論文はスパース表現を用いた画像修復の問題、多焦点画像と医用画像の融合問題について検討し、新しい修復方法と融合方法に対する知見が得られており、将来的な高精度画像処理の発展に寄与するところが大きいと考えられる。

よって、本論文は博士（工学）の学位論文として合格と認める。