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A Review on Multimodal Medical Image Fusion

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Abstract – Algorithms and devices of multimodal medical image fusion have shown notable achievements in raising the clinical accuracy of decisions based on medical images. In this paper procedure for multi modal medical image fusion and applications of medical imaging modalities have been described .The fusion of medical images has established to be helpful for the treatment of various diseases.

***Key Words –** Image fusion, Medical imaging, MRI, SPECT, PET, CT*

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I. INTRODUCTION

In recent years, medical imaging is being used at large by clinical professionals for explicit diagnosis and treatment of diseases. MRI, CT, PET other modes of medical images reflect human information from numerous angles. CT reflects the complex body part of bone tissues. It provides elaborated cross-sectional views of all kinds of tissues. MRI reflects the complex body part of soft tissues, organs, and blood vessels. As a result, the anatomical and practical medical images are required to be combined for a compact view. For this purpose, the multimodal medical image fusion has been known as a promising solution that aims to integrate information from multiple modality images to get a lot of complete and correct description of the identical object. In the clinical diagnosis and treatment, the problems regarding comparison and synthesis of images like CT-PET, MRI-PET, and CT-MRI were frequently encountered. To provide a lot of useful information for clinical diagnosis, there is a need to combine useful information from different source images. Combining complementary information from totally different images defined as image fusion. For example fusion of CT-MRI images is used to assist in planning the surgical procedure. Combination of MRI-PET images are used in detecting brain tumors, SPECT-CT is useful in abdominal studies and ultrasound images-MRI for a vascular blood flow test.

II. LITERATURE SUREVY

Padmavathi, MayaV. Karki [1]—In this paper the high resolution Magnetic Resonance Imaging and a low resolution PET/SPECT images of brain tumor are used for fusion. MRI images in gray scale, while PET and SPECT are in pseudo color. A new method of integrating DTCWT-PCA with IHS transform for fusion is used. IHS-DTCWT-PCA fusion with Histogram matching, the fusion process preserve spatial information, directional information & color details of PET& SPECT images. Standard Deviation, Entropy, PSNR and MI are considered for comparison.

C. Karthikeyan and B. Ramadoss [2] —In this paper, the technique for medical image fusion based on DTCWT and SOFM is proposed. In this technique firstly the image is registered than the fusion takes place between the registered image and the image that is to be fused based on the DTCWT method. To recognize and extract the features SOFM based network is used. For the resultant coefficient of CT and MRI this network would be trained. After decomposition, the method is carried out on each sub band independently. The image fusion based on DTCWT and SOFM provides better EBSM and SSIM.

Yoonsuk Choi, Ershad Sharifahmadian, Shahran Latifi [5] — In this paper the fusion results of four different fusion methods are Wavelet transform, Curvelet transform, Contourlet transform , Non sub sampled contourlet transform are compared and analyze in transform domain. For perfect comparison between these transforms different quality performance matrices are used. For spectral analysis CC, SID, SAM, RASE are used. For spatial analysis AG, E, UIQI, and SNR are used.

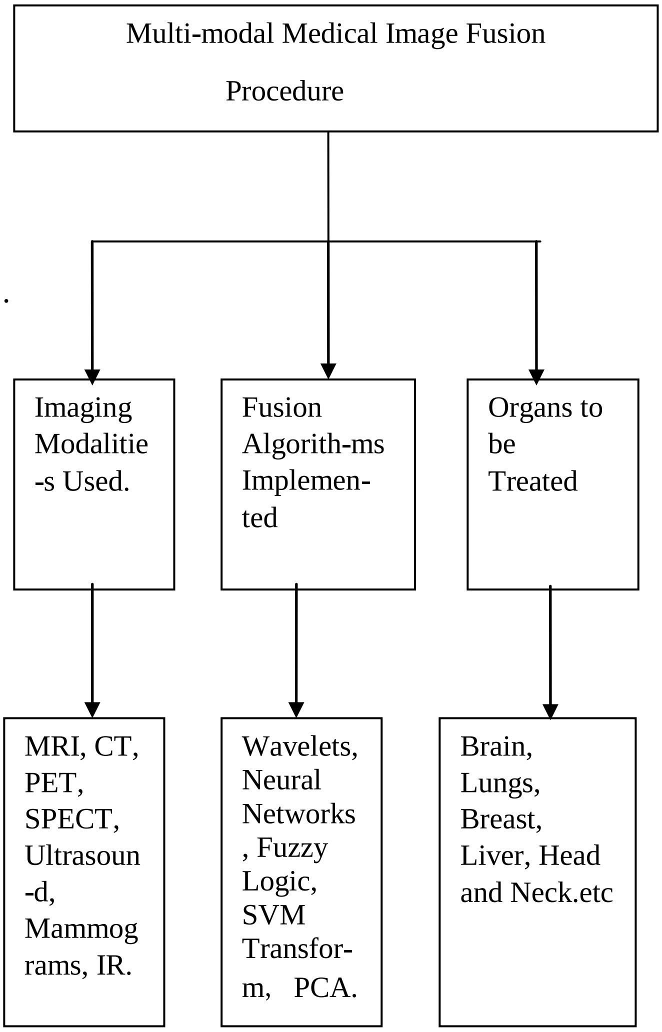
III. PROCEDURE OF FUSION OF MULTI MODAL MEDICAL IMAGES

Medical image fusion process especially multi-modal medical image fusion process aims to improve the imaging quality by reducing the redundancy to increase the clinical applicability of the medical images in diagnosis and medical problems assessment. The algorithm of fusion depends on inputs. So, the algorithm of fusion is shown in fig 1.

Fig.1 imaging modality used organs to be imaged and algorithm of fusion implemented.

Imaging modalities focus on different modalities like MRI, CT etc.
Fusion algorithms focus fusion of medical images and their assessment.

Organs studies focus on the application organs under concern such as brains, breast, lung ….etc.



IV. MEDICAL IMAGE MODALITIES

Numerous medical imaging modalities exist with each having distinctive characteristics that provide various sources of information that facilitates study of organs, diagnosis of diseases, follow-up treatments of patients, and for further processing procedures such as fusion process. Table introduces a summary about imaging modalities usage, applications, and observed the advantages and disadvantages of each modality.

CT

Body Part:

Bones and hard tissues

Example: bones, the pelvis, abdomen, blood vessels, brain, lungs, and heart

Applications: 3D tumor simulation, brain diagnostic and treatment, tumor detection, deep brain simulation, bone tumor surgery.

Advantages:

- Short scan time
- High resolution
- Wider scan area

Disadvantages:

- Limited tissue characterization
- Limited sensitivity
- Exposure to x-ray radiation
- High dose of radiation per examination
- High cost.

MRI

Body part

Soft tissue and non bony parts Example: blood vessels, organs in pelvis, breasts, bones and joints chest, abdomen (heart, liver, kidney), and tendon and ligament tears

Applications

Prostate studies, image regeneration, lung/liver diagnosis, tissue classification, cancer assessment and diagnosis, surgical planning and training

Advantages:

- Safe for babies and pregnant women
- No radiation exposure
- Higher accuracy
- No short term effects

Disadvantages:

- Relative sensitivity to the movement of patients and organs that involve movement
- Strong magnetic field disturb
- Cannot be used for patients with metallic devices such as Pacemakers
- Low through put High cost

PET

Body part

Provides physicians with information about how tissues and organs are functioning

Applications

Cancer treatments, gross tumor volume detection, image segmentation and integration, gynaecological cancer diagnosis, 3D tumor simulation, inertial electrostatic confinement fusion

Advantages:

- High sensitivity
- Provides a functional imaging capability.
- Effectively used to distinguish between benign and malignant tumors in single imaging.
- Can image biochemical and physiology Phenomena.

Disadvantages:

- Limited resolution
- Radiation
- High cost
- Motion artifacts
- Interpretation is very challenging

SPECT

Body part

Used to study blood circulation to tissues and organs

Applications

Brain diagnosis and treatment, neck, head, cancer diagnosis, liver diagnosis, lung cancer treatment, fusion of multi-modality images, tumor detection, and multi-dimensional visualization

Advantages:

- High sensitivity (but lower than PET)
- Higher penetration depth

Disadvantages:

- Limited resolution
- Radiation
- Attenuation
- Bluring effect
- High cost

ULTRASOUND

Body part: Non bony organs.

Applications

Organs in the pelvis and abdomen, pregnancy, breast cancer detection, abnormalities in the heart and blood vessels, esophageal cancer diagnosis, and liver tumor

Advantages:

- Low cost
- High spatial resolution
- Noninvasive (no noodles or injections)
- Widely available
- No radiation.

Disadvantages:

- Operator dependent
- Difficult image of bone & lungs
- Attenuation can reduce the images' resolution

V. DISCUSSION

The field of medical diagnostics using medical images faces several technological, scientific and societal challenges. The technological development in imaging technologies has resulted in improved imaging accuracies. However, each modality of imaging has its sensible limitations, which is further imposed by the underlying nature of the organ and tissue structures. This enforces the need to explore the possibility of newer imaging technologies. The ability of image fusion techniques to quantitatively and qualitatively improve the quality of imaging features makes multi-modal approaches efficient and accurate relative to unimodal approaches. The availability of an outsized variety of techniques in the feature process, feature extraction, and decision fusion makes the field of image fusion appealing to be used by the medical imaging community. The main challenge in applying image fusion algorithms is to ensure medical relevance and aid for a better clinical outcome. The right combination of the imaging modalities, feature processing, feature extraction and decision fusion algorithms that targets a specific clinical problem in itself is a challenging and nontrivial task. Even the same images under consideration often require very different types of processing for different types of diagnostics over a region of interest. The major issues concerning feature processing and extraction algorithms resulting from the presence of pixel intensity outliers, missing features, sensors errors, spatial inaccuracies, and inter-image variability remain an open problem in medical image fusion. The inaccurate registration of the objects between the images is tightly linked to the poor performance of feature or decision level fusion on medical image fusion algorithms and requires medical domain knowledge and algorithmic insights to reduce the fusion inaccuracies. Another medical image fusion problem is imaging quality and regions of interest within images. Also, the estimation of signal noise and compensation is considered as an important problem in medical imaging and the advancements in enhancements to image quality can have a positive impact on the image fusion process. Another area of interest is to improve the speed of processing especially in the cases of volumetric image fusion. The speed is of primary importance in real-time image fusion during surgery or that involve continuous real-time monitoring. In conclusion, image fusion techniques in terms of medical image modalities and organs of study have been discussed. The availability and growth of a wide range of imaging modality have enabled progress in medical image fusion to be helpful for clinical preparation. In addition to medical reasons, there exist technical challenges in image registration and fusion resulting from image noise, resolution difference between images, inter-image variability between the images, lack of a sufficient number of images per modality, a high cost of imaging and increased computational complexity with increasing image space and time resolution. The problem is far additional vital in developing image fusion algorithms and devices for period medical applications like robotic guided surgery. Since many of those challenges stay open and therefore the image fusion in medical imaging has proved to be helpful and therefore the trust in these techniques is on the increase. It is expected that innovation and sensible advancements would still grow within the future years.

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