题目：基于生成对抗网络合成多模态医学影像的研究。

医学影像数据的采集和标注一直是医学影像处理任务中面临的挑战，尤其是基于配准多模态数据的应用。利用图像合成技术可以有效缓解这一问题。但医学影像包含复杂的生理结构信息，现有方法直接合成医学影像会生成不合理的结构、轮廓和不可控的病灶；合成多种模态的医学影像时如何确保模态之间的配准面临严峻的挑战；如何控制医学影像中最关键的病灶信息的合成也是一大难题；另外，合成影像和合成病灶需要一种客观的方式来验证和评估其性能。

针对这些问题，本研究提出了一种基于生成对抗网络的多模态医学影像合成方案，可从随机噪声合成具有指定病灶的配准多模态医学影像。多个数据集上的实验充分验证了合成病灶的有效性和合成影像的可用性。本研究的主要工作包括：

1.本研究提出了一种基于Sobel算子的结构特征图提取和生成方法，无需额外的结构信息标签或标签提取训练，可直接从真实影像提取出结构特征图并用于变分自动编码器的训练，最后得到的模型可从正态分布随机采样合成任意数量的结构特征图。

2.本研究提出了一种可控制病灶合成的多模态配准医学影像合成方案，可将合成的结构特征图与选定的病灶标签融合后再合成多模态医学影像，通过模态转换器提供合成多模态之间的转换一致性约束以确保合成多模态之间的配准，通过病灶处理器实现对重建合成影像病灶标签的约束从而确保合成影像根据输入标签生成对应病灶。

3.本研究使用多项通用指标对合成影像的质量直接评估，同时使用合成影像训练智能医学影像处理模型，通过评估训练好的模型间接评估合成影像的性能。结果表明合成影像可在多种任务中通过用于预训练和数据增强来提升模型性能。

Title: Research on Multimodal Medical Images Synthesis Based on GAN

The collection and annotation of medical image data have always been a challenge in many data-driven medical image processing tasks, especially for those based on registered multimodal medical image data. This can be largely alleviated by utilizing the image synthesis technology. However, medical images contain complex physiological structure information, and the directly-synthesized medical images generated by current methods usually have unreasonable structures or contours and uncontrollable lesions. The registration of different modalities when synthesizing multimodal medical imagesremains difficult. How to control the synthesis of the most critical lesion information in medical images is also a major problem. In addition, an objective way is needed to verify and evaluate the performance of synthetic images and lesions.

To solve these problems, this study proposed a multimodal medical image synthesis method based on Generative Adversarial Networks, which can synthesize registration multimodal medical images with specified lesions. Experiments on multiple datasets have comprehensively verified the effectiveness of synthetic lesions and the availability of synthetic images. The main contributionis as follows:

1.This study proposed a structural map extraction and synthesis method based on Sobel operator, which does not require additional structural information labels or label extraction training. The method can extract structural map directly from the real images and then fed it to Variational Auto-Encoder for training. Finally, the trained model can achieve any number of structural maps synthesis from the normal distribution.

2.This study proposed a multimodal registration medical images synthesis scheme that can control lesion synthesis. The randomly generated structural maps are used to fuse with the selected lesion labels and then synthesize multimodal medical images. The modal translator constrains the consistency of the translations between the multimodal synthesis and ensures the registration between the multimodal synthesis. The lesion processor constrains the restoration of the lesion label in the synthetic image to ensure that the synthetic image generates a corresponding lesion according to the input label.

3.In this study, two general indicators were used to directly evaluate the quality of the synthesized images. Meanwhile, the performance of the synthesized images was indirectly evaluated by applying the synthesized images to the training of intelligent medical image processing tasks and evaluating the trained models. The results shown that the synthesized image can be used for pre-training and data augmentation in a variety of tasks to improve model performance.