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Paper Critique Report

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High-Quality Multimodal Volume Rendering for Preoperative Planning of Neurosurgical Interventions

Brief Discussion

As advances are being made in surgical approaches, minimally invasive procedures are gaining importance so as to minimize surgical trauma, shorten recovery times and reduce postoperative complications. The authors have presented a pre-operative planning of neurosurgical approach based on multimodal volume rendering. The whole procedure can be summarised in the following steps: Data acquisition, registration, segmentation, planning of the skin incision and bone removal area, brain surface visualization, and surgery planning for deep-seated structures, tailored to the individual anatomy. At the pre-processing stage, different datasets such as CT, MRI, PET, DSA etc. are aligned and resampled. The first part in the interactive stage is skin incision and bone removal. CT scans which depict the bony structures and MRI data which show the soft brain tissues are used in the skull peeling algorithm. It displays the unoccluded part of the brain and provides an ideal position for skin incision and bone removal. However, this being view-dependent, a depth image is generated using the depths where the rays first hit a non-peeled area. After obtaining the unobscured view of the brain, surgeons might want to have additional information of the brain. For combining multiple modilities, techniques like linear blending is used. After this, there might be a need of emphasising certain objects like optical nerves or tumors which is carried out by rendering specific area of interest. The smooth rendering algorithm uses iso-values and gradient direction to smooth out the staircase artifacts if any present in the segmented rendering objects.

Advantages

Preoperative planning for neurosurgery has been taken up as an active field of research in the recent years but the authors in this paper have come up with a technique which not only helps visualise multimodal data fast and in high quality but also minimises user interaction. The foremost thing to consider in multimodal rendering is volume management and the authors have done the same efficiently. They have employed bricked volume rendering scheme wherein only active bricks of the volume are held in the gpu. High quality rendering of brain is required which if done without segmentation, then the brain gets occluded with neighbouring elements. Unlike other methods which make the task cumbersome for the surgeons and are very much sensitive to the user defined parameters, skull peeling algorithm displays the occluded part of the brain without segmentation. The authors further developed this view dependent skull peeling algorithm to be view independent by generating a depth map. The generated mask allows to switch back to standard volume rendering with segmented masks, toggling the visibility of the peeled area on demand while it stays constant with respect to the volume, even when the view is changed. The main visual problem of rendering binary segmented objects are the staircase artifacts that appear at object boundaries. Techniques like trilinear filtering can improve the visual appearance but cannot completely eliminate the artifacts. The paper answers this issue by proposing the smooth rendering method. The main advantage of our algorithm is that even inexact segmentation masks (e.g., slightly too small or too large masks) can be rendered correctly and with a smooth appearance because the object boundary is adapted to the actual underlying data. As can be concluded from the results section, the proposed approach helped the surgeons to pre plan the surgery leading to minimal invasion.

Limitations

In the pre-processing stage, various datasets have to be collected and registered. Although an automatic registration algorithm has been proposed, if the result is not satisfactory which is the case most of the times, manual registration is to be done making the surgeon's work more tedious. During skull peeling, both CT and MRI data is required and many a times a registered CT dataset is not available. Multi volume blending requires two or more registered inputs but the technique used differ on the kind of datasets used. Because of the absence of an automatic combination selection method, the surgeon has to himself decide the technique. Furthermore, a lot of parameters have to be set during the rendering of segmented masks. These were provided to offer flexibility in visualisation but they actually reduce the ease of use because of the amount of manual work required. This method does not allow the surgeons to visualize other intricate details such as neuronal pathways or the already registered datasets while the surgery is in progress which could further reduce the invasiveness and increase the security of such operations.

Deskewing of Underwater Images

Brief Discussion

Underwater images can suffer from a lot of degradations like color loss, noise due to floating particles, low contrast, skewing and blurring. Imaging through dynamic water surface is important for coral reef monitoring, examining the contamination of shallow waters, mapping the distribution of vegetation and seabed sediments etc. Thus restoration of such images is becoming an important field of study.

In this paper, the authors have proposed a method to restore underwater images degraded from blur and skew. Firstly, they have used physics to analyse the image formation under water and have reached to the conclusion that translation undergone by pixels vary spatially thus leading to skew in the UW images. Blurring can be attributed to the dynamic nature of the medium. The blurred image can be seen as an average of all the skewed versions recorded during the exposure time. The authors have further derived a mathematical model for blur in terms of the point spread function which represents the fraction of time that the light ray spent in a particular position that caused the transformation λ and the homography matrix which transforms the pixel **x** according to transformation λ. To restore the image, MAP is employed. By Bayes Theorem, to compute the map, the likelihood, prior on latent image and point spread function is calculated. The estimation is done using an iterative procedure where the negative log of a posteriori probability is minimized. Unlike UCW, the deblurring caused due to circular ripples is space variant. However, this is only true for rectangular coordinates. For restoration, the image is first transferred to polar domain and the same procedure described for UCW is followed here as well. The methodology was tested on both real and synthetic experiments and has been claimed to perform better than the existing state-of-the-art techniques.

Advantages

The authors in this paper have proposed a novel method for restoring skewed and blurred underwater images. Although many other techniques do exist but they only consider distortions due to skewness and treat motion blur as almost negligible. In this approach, the authors have solved the problem using a unified framework. Contrary to the other methods whose requirement is that the exposure time must be less so as to avoid any blur, this one actually relies on the fact that exposure time is more. Moreover, other methods require multiple observations for the restoration part but only one observation is sufficient here. Hence, it is more efficient and faster as well. Another advantage of the proposed method is that it is valid for any type of UCW and does not assume any functional form of the underlying wave. The method described outperforms other technique in terms of restoration of skewness not only qualitatively but also quantitatively. The authors have also compared their results against a well-known deblurring algorithm and have obtained better results than them as well. So, this approach displays good results in restoration of both skewed and blurred images under any type of UCW and that too in a shorter time.

Limitations

Though, the authors have considered both skewness and motion blur, they have assumed that the light ray suffers negligible attenuation and scattering. The only cause of distortion is attributed to dynamic refraction occurring at the surface of the water, which changes the direction of the incoming light. To keep the attenuation negligible, they have assumed a limited field of view. So, the effects on the images due to attenuation cannot be restored using this approach. In the experiments where distortions due to circular ripples have been considered, the origin of the ripple is made to coincide with the image center which cannot be the case always in real life and there is a possibility of not obtaining such good results in those cases.