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研究課題名（和文）GPUの深度画像並列処理機能による肝臓手術ナビゲーションシステムの製作とその評価

研究課題名（英文）Production and evaluation of a smart navigation system for liver surgery by matching real and virtual depth images based on parallel processing of GPU

研究代表者

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研究成果の概要（和文）：肝臓手術ナビゲータを製作し、手術室で利用できるかどうか評価した。
　まず、z-bufferと深度画像のマッチングより、仮想肝臓と実肝臓の位置・姿勢を合致させた。次に、無影灯2台が術部を照射する手術室で、前述のマッチング誤差を最小化する探索アルゴリズムを最急降下法から焼きなまし法に変更したり、遮光フィルタで無影灯を蓋ったりし、仮想肝臓が実肝臓を追従する誤差が1cm以内になるようにした。さらに、前述のマッチング誤差を小さくするように仮想肝臓の形状を変化させるようにした。最後に、メス先が３脈管や癌組織に過度に接近したら、色彩・音声・振動で医師の注意を喚起し、次のメス動作を医師に提示する機能も付加した。

研究成果の概要（英文）：The liver surgery navigator was produced and evaluated in some operating room. First, based on matching the depth image with z-buffer, the position and posture of the virtual liver and real liver were matched. Then, in the operating room where the surgical area is irradiated with two non-shadow lamps with or without several light-shielding filters, we change the search algorithm to minimize the aforementioned matching error from the steepest descent method to the simulated annealing method. The error that the virtual liver follows the real liver was to be within 1 cm. Furthermore, we changeed the shape of the virtual liver to reduce the matching error described above. Finally, when the tip of CUSA (cavitron ultrasonic surgical aspirator) scalpel is excessively close to three types of blood vessels and tumor tissue, the function of arousing the doctor's attention by color, voice, and vibration, and also presenting the next operation of CUSA scalpel to the doctor was added.

研究分野：知能機械学・知能情報学

キーワード：手術ナビゲーション　GPGPU　並列処理　深度画像　Zバッファリング

１．研究開始当初の背景
肝臓を手術するナビゲーションシステムはほとんどなく、また肝臓癌の手術を受けたい多くの患者が存在していた。

２．研究の目的
医師が肝臓癌を摘出する際、太い血管を誤った切断し、患者の生命を危機に陥らせないようにするナビゲーションシステムを製作する。

３．研究の方法
以下の順序で、肝臓手術ナビゲーションシステムを構築する。

A)術前に CT/MRI スキャンした DICOM から３脈管や癌組織を抽出し、それらを STL 多面体に変換し、仮想肝臓 STL と実肝臓 の位置・姿勢および形状を合致させる。

B)実肝臓の挙動を深度カメラでリアルタイム計測し、その深度画像と仮想肝臓 STL の z バッファが合致するよう、仮想肝臓 STL を平行・回転・変形させる。

C)肝臓表面の形状変化に伴って、肝臓内部の３脈管や癌組織の STL 多面体の頂点の Z 座標を更新し、それらの多面体を独立に変形させる。

D)メス先から３脈管および癌組織までの距離を閾値処理し、それらに過度に接近した場合、色彩・音声・振動で医師に注意を喚起する。

E)直近のメス動作ベクトル、メス先端と３脈管上および癌組織上の近接 2 点ベクトル、およびそれらのユークリッド距離を利用することで、次に 推奨されるメス動作ベクトルを実時間で医師に提示する。

４．研究成果
(A) に関しては、手動では、動作入力装置の種類や個数を変えて、最も合致させやすい組み合わせを求めた。一方、半自動では、SLAM (Simultaneous Localization and Mapping) における合致精度を評価した。

(B) については、無影灯 2 台が術部を照射する手術室で、追従アルゴリズムを最急降下法から焼きなまし法に変更したり、遮光フィルタで無影灯を蓋った りしたりして、許容精度 1 ㎝が得られるようにした。

(C) に関しては、各 種の物理パラメータを変更することで一定の追従性が確認できた。

(D) および (E) は完成した。メス先と血管の距離が小さすぎて危険な場面では、背景色を代えたり、音声や振動で知 らせたり、メスに取り付けた LED 表示器で知らせたりした。

以上のことから、医師のメスを最適誘導する手術ナビゲータシステムが完成した

５．主な発表論文等
（研究代表者、研究分担者及び連携研究者には下線）

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