Surgical Entry Spot Location Developer Software for Neurosurgeries

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ABSTRACT
Neurosurgery is a complex and delicate craft where a neurosurgeon needs to reach the tumors or lesion present deep inside the brain with precision, accuracy and safety, minimizing the damage caused to the brain tissues. The entry point and the trajectory of the tool above the skull are crucial in the case of neurosurgeries as a small error can cause death of the patient since there are number of major blood vessels and nerve cells present beneath the skull. So, as a first level for performing the neurosurgery, the entry spot and the trajectory of the surgical tool need to be fixed. This work focuses on the development of software which will help in extracting the entry point location for the surgical tool above the skull in neurosurgeries. Initially a 3D image of the patient was reconstructed from number of 2D head CT slices by the software using contour slicing and isosufacing techniques. Then, using this software the surgeons can extract the location of the entry spot from the developed 3D image. Also the surgeon can check and verify the entry spot location before actually performing the surgery. A GUI was also developed for this software which makes it easy to handle even for a common man. Using this GUI the surgeon can easily determine the location and these coordinate points can be serially transmitted to the controller for performing robotic surgeries.

General Terms
Entry spot, trajectory, 2D, 3D, neurosurgeon, surgical tool, visualization

Keywords
Neurosurgery, Cartesian coordinate location, GUI, image processing

1. INTRODUCTION
Rapid development in the field of image processing has changed the medical practice drastically throughout the world. It is hard for the doctors to carry out the diagnosis without using any of the imaging modalities like X-rays, CT and MRI scans so as to arrive at a conclusion. In case of neurosurgeries, it is a complex and delicate craft, where it is highly crucial to avoid damaging the functional areas and major blood vessels of the brain [1]. In early 19^{th} century, neurosurgery required large opening of skull and then the surgeons should find landmarks to reach to the surgical point present deep inside the brain. Opening of skull will lead to bleeding, CSF leakage and even brain swelling. Even an experienced surgeon can make mistakes while doing surgery. These will lead to further complication such as paralysis, coma, and speech deficit or can even lead to death. This paved the way to the research and development for better visualization of target present deep inside the brain as well as the entry point into the skull so as to perform safe and secure neurosurgery minimizing the damage caused to the brain. This paper discuss about the development of low cost user friendly imaging software which helps the surgeons in fixing the entry point of the driller so as to perform the surgery.

2. LITERATURE SURVEY
During neurosurgery, a surgical tool like a driller, electrode or a biopsy probe is guided deep into the brain to the surgical target fixed by the surgeon. Earlier x-rays were made use to fix the target deep inside the brain. Then these were replaced by evolving techniques like CT and MRI scans. Using these techniques the surgeons were able to visualize each minute structure present inside the brain [2]. This makes it easy for surgeons to fix the target with greater accuracy.

It requires a straight line trajectory for its movement to accurately reach the target. By maintaining a straight line trajectory to reach target, it will minimize the brain damage thereby avoiding vital brain regions and major blood vessels in the brain. Using the 2D images it's difficult for the surgeons to exactly fix the target point. Also it is hard to choose the entry point of the surgical tool as the surgeons cannot exactly visualize the blood vessels or nerves placed beneath it. Since the surgical target is present deep inside the brain, a 3D visualization of the target area is required before carrying out neurosurgery. This gives the surgeon detailed information about the target as they do not have any direct visual contact with the target. Using this 3D map they can fix the exact location of the target, the angle of insertion of the probe and also can calculate the depth at which the target is present [3]. Usually scanning devices like X-rays, CT scans and MRI are made used of to obtain the 3D maps of the area.

Nowadays, the target points are fixed by the surgeons from the 3D images obtained using various imaging modalities like CT or MRI [4]. So it is highly necessary to determine the entry point and set the trajectory of the surgical tool to reach the destination thereby causing minimum damage. During the work, simple low cost software was developed using MATLAB which will generate the coordinate location of the entry point automatically. This point can be used by the surgeons to fix the landmark or could be transferred to the controller system. Thus the entry point and the trajectory for the surgical tool can be fixed.

3. METHODS AND ALGORITHM
Initially, 2D slices of the brain CT scan were obtained and this formed the dataset for the experiment as shown in figure1.

The dataset contains number of slices of a single CT scan.

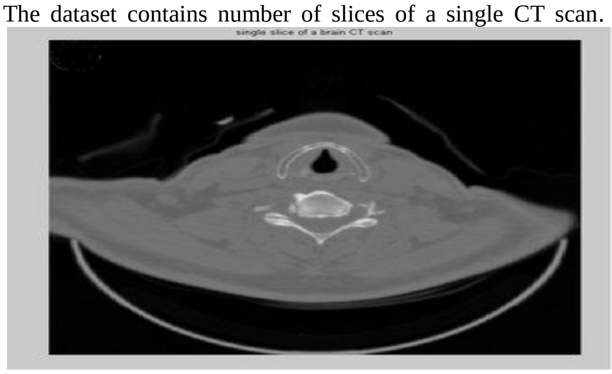

Fig 1: Single slice of a CT scan

Here the 2D CT images from the dataset are stacked up one on the other and then image fusion is carried out to obtain 3D model [5]. Using contour slicing each of these slices is displayed in 3D orientation [6]. This makes each of the slices to orient in 3D axis. Then isosurfacing is applied so as to obtain points of same density within a volume from each slice. It envelops regions of same density. On isosurfacing it displays the overall structure of a volume. On applying isocaps of same isovalue gives the detail of the interior. Patching and interpolation was carried out in order to join between slices and thus a 3D model was developed from 2D slices of CT scan [4], [6]. The reconstructed 3D image is obtained as shown in figure 2.

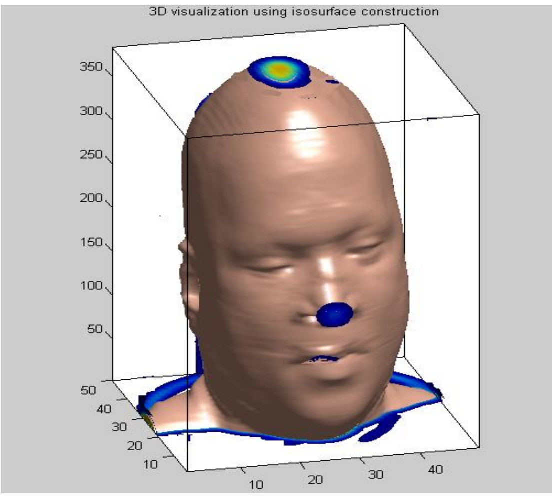

Fig 2: 3D visualization

A GUI was developed as shown in figure 3 for this software which makes it easy for the surgeons to fix the entry point and the trajectory. Using this GUI the surgeons can visualize the 3D image of the person and they can freely select the point at which the surgery needs to be carried out. The coordinate location of the entry point will be extracted with the help of datacursor mode in GUI and it can used for fixing the landmark on head for manual operations or it can transferred to the controller for robotic systems [7]. The location will be displayed in Cartesian coordinate system which make it highly user friendly. This makes the verification of the entry point on the skull simple and accurate for the surgeons. Position values up to 4 decimal points will be obtained from the software developed. Using these coordinate points the surgeons can easily locate the landmark, if they are performing the surgery manually. The GUI also provides the provision for operating with robotic systems. The coordinate points can be easily transferred to the control systems thereby which it can position to the desired location via the serial port of the system. Also the control system can be resetted to the initial position after performing the surgery using this GUI.

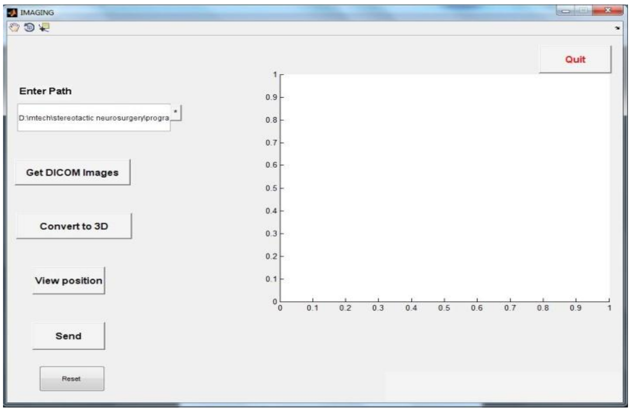

Fig 3: GUI developed for the locator software

4. RESULTS

Initially the images are loaded into the MATLAB and it can be viewed in the GUI as shown in figure 4. For the present work, a database containing 382 DICOM images of head CT scan was obtained and each CT slice can be viewed in GUI for diagnosis by the surgeons.

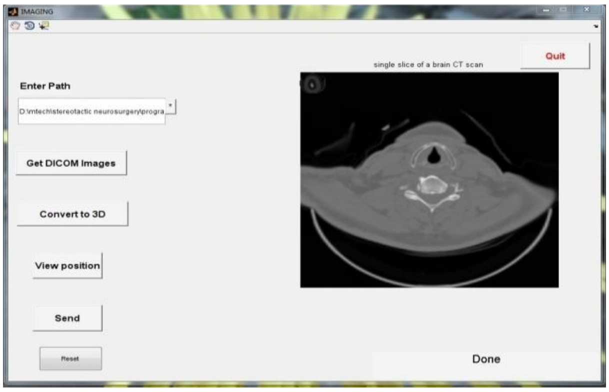

Fig 4: 2D CT image in GUI

Using the developed GUI the 2D CT images are converted to 3D by the proposed algorithm. Figure 5 shows the 3D visualization developed using the isosurface construction in GUI.

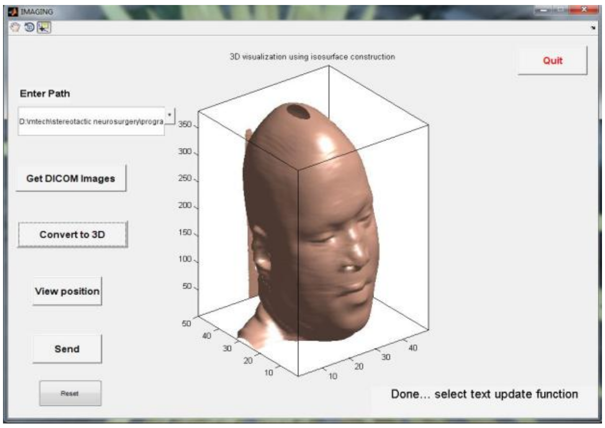

Fig 5: 3D visualization in GUI

Next the surgeons fix the entry point as well as the trajectory to reach the target. So now they can place the cursor on the 3D image in GUI and fix the entry spot. Upon pressing the corresponding push buttons provided in GUI as shown in figure 6, the coordinate location of this spot will then be extracted as proposed in the algorithm and it will be displayed in the GUI.

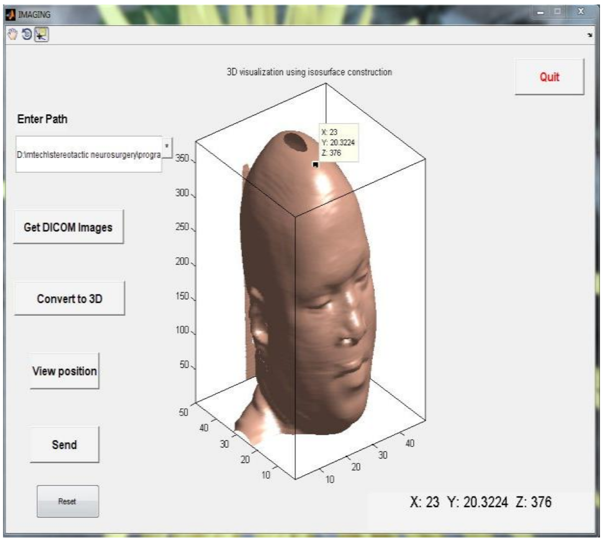

Fig 6: Coordinate locations are extracted from the 3D image

The three coordinate location of the entry spot is obtained from the image and this can be used by the surgeons for driving the surgical tool deep inside into the brain making it easy and more user friendly. Also this software can be used along with robotic systems to perform the surgery. Here this coordinate location can be sent to the controller using the serial port from MATLAB by which the controller can position the surgical tool as shown in figure 7.

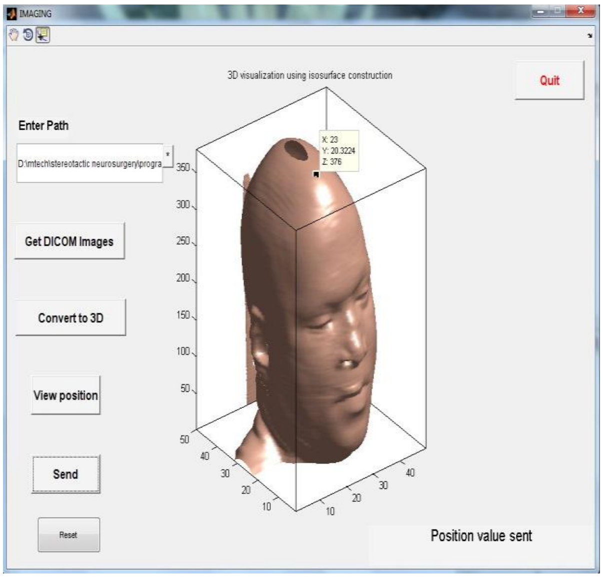

Fig 7: Coordinate values are sent to the controller using the software

5. CONCLUSION

A low cost, user friendly software was developed which would help the neurosurgeons in obtaining the location of entry point above head as well as to position the surgical tool so as to reach the target deep inside the brain with minimum damage. By using the proposed algorithm a 3D image was developed and the coordinate location of the entry point was extracted from it. A simple GUI was also developed as a part of the work which can be operated even on a simple PC to plan and verify the entry point before performing the surgery. The developed software can be used along with both manual and robotic neurosurgeries.

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