# 摘要

本研究主要開發一套用於神經外科的手術機械手臂鑽孔導航系統，提供完整的骨骼鑽孔作業流程，醫師可於人機介面端進行術前的路徑規劃，依照規劃內容控制機械手臂進行鑽孔導航，執行自動化的骨骼鑽孔，並於影像當中顯示鑽孔進度，輔助醫師進行手術。系統包含了三個部分：(1)手術機械手臂導航，使用機械手臂的位置精確度配合手術導航定位，(2)三維醫學影像手術規劃軟體，在三維的醫學影像中規劃手術路徑，得知病灶位置與避開危險區域，(3)自動化骨骼鑽孔控制，在骨骼即將鑽透的時候自動停止鑽孔並收回鑽頭。

針對本研究所提出的方法與功能，為了驗證其可行性與準確度，在醫師的指導下共設計了三項實驗：(1)機械手臂導航精確度實驗，從三維醫學影像對應於機械手臂可控制其導航位置的誤差在0.50±0.06mm。(2)危險區域自動路經規劃實驗，在自動避開危險區域的路徑規劃方法上與醫師手動規劃的相關性達 0.975，自動規劃與危險區域間距平均誤差為 0.279±0.401mm，操作方式較簡單且速度亦較快。(3)骨骼鑽孔自動停止實驗，選用豬肩胛骨進行動物實驗，利用不同的骨骼部位總共進行 95 次的鑽孔，控制鑽孔停止位置在骨骼的剩餘厚度 0.24mm±0.21mm 到鑽透骨骼超出 0.25mm±0.19mm 之

間，其中 70.5%為不鑽透、29.5%為鑽透。由實驗結果證明本研究方法與功能的可行性達一定標準，期望能夠提供更加安全可靠的手術鑽孔品質、縮小手術傷口、節省醫療資源，有助於患者的康復並早日回歸日常生活。

關鍵字－機器人、手術導航、手術路徑規劃、骨骼鑽孔。

# Abstract

The purpose of this study is to develop a surgical robotic arm drilling navigation system for neurosurgery that provides a complete bone drilling processes. The physician can not only do the path planning in man-machine interface before surgery, but also control the robotic arm to drill by the path with navigation. Besides, our system can help physician automatically drill the bone and show the progress rate of drill on the monitor. The system combines three parts, including: (1) Surgical robotic arm navigation: It combines the accuracy of robotic and surgical navigation. (2) 3D medical imaging surgical planning software: It can identify the lesion location and plan the surgical path on the 3D image. (3) Automatic bone drilling control: It will stop drilling when the bone soon to be drilled through.

We designed three experiments to verify the feasibility of our method and the accuracy of the function in this study. The experiments were instructed by physician, including: (1) Robotic arm navigation accuracy experiment: The average errors of positions from the 3D medical image to the robotic arm by navigate is 0.50±0.06mm. (2) Danger area automatic path planning experiment: The correlation between the path to avoid the danger area by manual and automatic is 0.975. The average errors of distance between path and danger area is 0.279±0.401mm. The automatic path planning is more quick and easy. (3) Automatic bone drilling experiment: We used pig scapula to do animal experiment, and drilled different parts a total of 95 times. The

average remaining thickness of bone is 0.24mm±0.21mm (All of 70.5%). The average length of bone be drilled through is 0.25mm±0.19mm (All of 29.5%). The experimental results demonstrated the feasibility of the method and function is statistically significant. In summary, we expect to provide more secure and reliable quality of surgical drilling, in order to help patients get well soon and return to everyday life earlier.

Keywords—Robot; Surgical Navigation; Surgical Route Planning; Bone Drilling.