International Journal of Innovative
Computing, Information and Control
Volume **7**, Number **11**, November **2011**

ICIC International ©2011 ISSN 1349-4198
pp. **6523–6539**

A MEDICAL AUGMENTED-REALITY SYSTEM FOR IMAGE-GUIDED SURGERY USING MARKER-ADDED ICP

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Received July 2010; revised December 2010

Abstract. *Image-to-physical registration is critical for reliable anatomical information mapping and spatial guidance in image-guided surgery (IGS) systems. Conventional stereotactic frame-based or fiducial-based approaches provide accurate registration but are not patient-friendly. This study proposes a frameless cranial IGS system that uses computer vision techniques to replace the frame or fiducials by with the natural features of the patient. To perform a cranial surgery with the proposed system, the facial surface of the patient is first reconstructed by stereo vision. Accuracy is ensured by capturing parallel-line patterns projected from a calibrated LCD projector. Meanwhile, another facial surface is reconstructed from preoperative CT images of the patient. A proposed Marker-added ICP algorithm (M-ICP) is then used to register the two facial-data sets, which brings the anatomical information from the CT images to the physical space. Compared with the adaptive ICP algorithm [8], experimental results reveal that the M-ICP algorithm is more practical and the registration accuracy is under 3-mm target registration error. Moreover, optical-based spatial digitizing devices can be integrated to further enhance surgical navigation. Anatomical information or image-guided surgical landmarks can be projected onto the patient by the projector to obtain an immersive augmented-reality environment.*
Keywords: Augmented reality, Image-guided surgery, Image registration, Iterative closest point algorithm (ICP)

1. **Introduction.** Image-guided surgery (IGS) has a grown role in clinical practice, especially in head, neck and brain neurosurgery. By combining highly accurate localization of lesion position based on preoperative anatomical images obtained by computed tomography (CT) or magnetic resonance imaging (MRI) with seamless integration of spatial digitizing devices, a well-designed IGS system can reduce the invasiveness of neurosurgical procedures. An important function of an IGS system is an interactive navigation system for guiding surgical instruments to reach the surgical target observed from preoperative images of patient. Navigation results are usually displayed on a standard computer monitor. However, recent integration of augmented reality (AR) techniques, semi-transparent screens, projectors and head-mounded displays now enables IGS systems to provide information-enriched surgical environments [1].

When performing a cranial IGS, a stereotactic frame is usually fixed to the cranium of the patient before CT or MRI imaging scan [2,3]. The stereotactic frame functions as a bridge connecting two coordinate systems, i.e., the coordinates between the imaging