Intelli-Cath: Toward Automated Needle-Insertion Systems and Intelligent Catheters

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Ninety percent of combat wound fatalities die on the battlefield before reaching a medical treatment facility. This fact emphasizes the need for improvements in combat medical care. As one example, needle insertion is pervasive in almost all medical activities. On the battlefield, combat medics administer pain medication and intravenous (IV) insertion to replenish fluids, possibly while under hostile fire. The development of a compact, lightweight automated needle insertion system will significantly reduce the risk to both patient and combat medic. Likewise, development of technologies that enables automated insertion of needles and catheters will clearly play a vital role in the Operating Room of the Future. One vision for future operating rooms is an environment void of any humans beyond the patient. Subsequently, future operating environments will require remote and autonomous insertion of IVs and catheters in a patient without the assistance of a nurse.

This presentation focuses on two key technical issues: (1) identification of the vein size, location and configuration and (2) active force control of the needle during insertion. We begin with a survey of current technologies and practices that are presently used for needle insertion. We then describe an infrared spectrometric vein-mapping system for identification of vein location and configuration. This system images the veins on the arm in a close-in display with infrared light-emitting diodes (Fig. 1). The device is mounted on a platform with the catheter (Fig. 2) so that the needle is also visible in the image displayed. Moving the device on the arm until the needle is positioned properly allows relatively easy manual use.

Fig. 1. Left wrist illuminated with a ring of 8 LEDs of 880 nm, without contrast enhancement.

The second problem described in this presentation is regulation of forces during automated insertion of a needle and catheter. We describe the design and control of an articulated syringe with full force measurement capabilities and illustrate force/torque profiles measured during controlled insertion in phantom arms. The objective of force-guided control is to ensure rapid and reliable insertion of needles and catheters with reduced trauma and risk of penetrating the far wall of the vein during insertion (Fig. 3). Finally, we describe how the combination of these two technologies enables an entirely new class of automated needle insertion tools that can be operated either in the field in unmanned first intervention medical cells such as the proposed Trauma Pod (see companion presentation in this session), or remotely in minimally manned medical facilities such as the concept of the Operating Room of the Future.

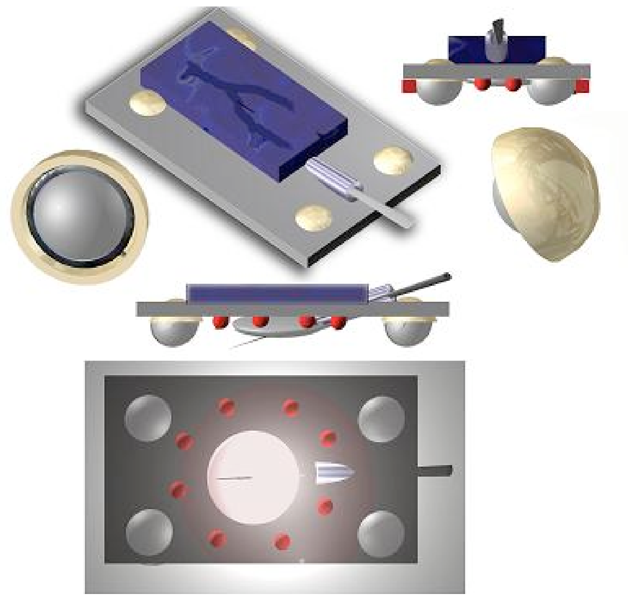

Fig. 2. Conceptual platform for manual scanning with infrared light emitting diodes.

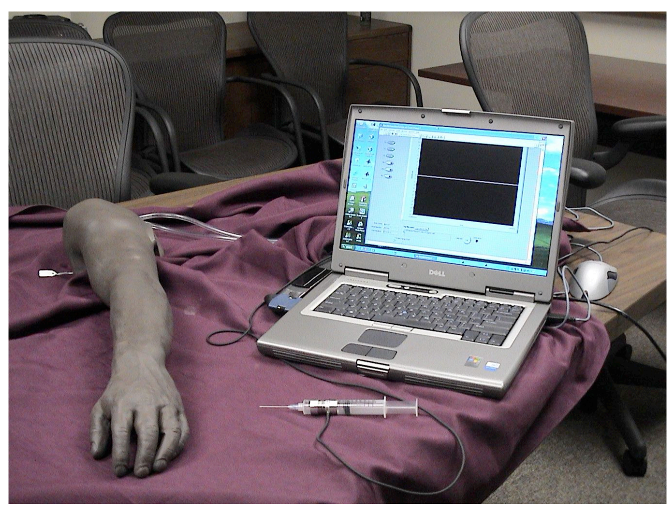

Fig. 3. Phantom arm and syringe instrumented with force and torque-measuring sensors used in the experimental studies of automated insertion.

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