Robot-Assisted Point of Injury Care
CCC Research Roadmap Proposal

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Emergency medicine is traditionally practiced where the point of care is different than the point of injury; that is, a victim is stabilized and transported to an emergency facility. This "hospital as the point of care" paradigm is being expanded to include ambulances, which are becoming mobile emergency rooms. Taking a page from science fiction, the US Army is pursuing roboticized ambulance "auto-docs."

Based on our extensive experience in search and rescue, we posit that a new direction for medical robotics is to ***expand the scope of point of care to the point of injury, where robots are used to provide medical workers with access to previously unreachable victims.*** Examples of unreachable victims include soldiers trapped by snipers and civilians trapped by a disaster or a car crash. Consider that victims of a building collapse can require 10 hours of extrication before physical contact with emergency personnel. A robot would be the only source of medical intervention or interaction with the outside world. Victims of car crashes may remain trapped for several hours with responders unable to access key areas of the body.

Robot-assisted point of injury care has many advantages for society. The use of robots to reach previously unreachable victims allows care to be given within the "Golden Hour," the critical first hour after the injury has been sustained. It allows medical specialists not affiliated with, or located at, the local hospital to become involved and provide care over the internet; for example, a specialist in crush syndrome in Seattle can diagnose and assist a worker trapped under a parking garage collapse in Miami. Robots for point of injury care complement the already established areas of hospital-based robotics and intelligent ambulances.

Robot-assisted point of injury care has at least ***three open basic research*** issues for robotics:

- *Non-contact physiological and situation awareness sensors.* A robot for point of injury care will require physiological sensors. The medical community has relied extensively on physiological sensors that require direct contact with the victim. Many of these sensors require contact with clean skin or in precise locations. However, access at the point of injury may preclude such interactions. Therefore a suite of non-contact sensors and sensing algorithms is needed. In addition to physiological sensors that allow medical personnel to diagnose the victim, sensors are needed to provide a general situation awareness of how the robot can move in the highly constrained work envelope (e.g., the interior of the crushed car).

- *Human-robot interaction between the robot and the victim.* The interaction between a robot and a victim has two major dimensions. One dimension is the affective response generated by the robot's appearance and mannerisms. A robot capable of navigating in human-denied spaces will mostly likely not be anthropomorphic in appearance, and indeed might have a disturbing snake- or scorpion-like shape. A second dimension is the use of the robot as a medium to the outer world. This raises questions of how the victim will interact with the humans "behind" the robot and what services the robot can provide. For example, trapped miners requested a MP3 player with a Foo Fighters album in order to pass the time while they were being rescued.

- *Human-robot interaction between the medical personnel and the robot.* Medical personnel will have to use the robot, raising questions of situation awareness, interfaces, and training. Complex manipulation is a challenge and traditional issues in teleoperation are exacerbated by the time-pressure associated with the task (i.e., hurry up or they die). Unlike high consequence applications such as nuclear power plants and planetary exploration which model the world and permit the operator to try out motions in a simulator, the operator will have to act without a complete world model, barring advances in sensing. In addition, teams of medical personnel may be required (e.g., the specialist in Seattle working with local doctors), leading to issues of distributed mixed teams.

There are at least ***two translational research issues*** for robotics that must be addressed in order for robots to be permitted to be used for point of injury care:

- *Establishment of the point of injury domain and priorities.* A domain analysis is needed to describe what a robot really needs to do and what the expected environmental conditions are. For example, a robot might be capable of injecting a victim with medication or a diagnostic probe, but if the robot cannot clean the insertion area of dirt, fluids from sewer lines in a building collapse, etc., beforehand, this could obviate the use of the robot.

- *Modifications to the START and other care protocols.* The medical community uses formal protocols to define how to conduct care; these protocols ensure uniform care and also reflect the best practices. These protocols are entirely based on medical personnel in direct visual, physical, and audio contact with the victim. Such contact cannot be guaranteed between a robot and a trapped victim. Without a validated protocol, robot-assisted point of injury care will not allowed due to liability.