Blood Detection Sensor and Automatic Tourniquet Saving Lives with and without Direct Human Interaction

Jänig C[1],Parhofer C[2], Ambros J[2], Lueth T[2], Biberthaler P[3], Kehe K[4], Steinritz D[5], Schmidbauer W[1]

[1]Bundeswehr Central Hospital Koblenz, Dept. of Anesthesia and Critical Care Medicine, Koblenz, Germany • [2]Technical University Munich, School of Engineering and Design, Munich, Germany • [3]Technical University Munich, School of Medicine and Health, Munich, Germany • [4]Bundeswehr Medical Academy, Munich, Germany • [5]Bundeswehr Bundeswehr Institute of Pharmacology and Toxicology, Munich, Germany

Introduction: Massive bleeding remains the number one preventable cause of death on the battlefield, while restrictive use or early conversion of tourniquets can prevent unnecessary amputations of limbs. Automated patient care systems can help save lives by applying tourniquets and by monitoring the effectiveness of bleeding control after conversion to pressure bandages to prevent secondary blood loss.

Capability Description: The developed system can detect blood and tighten a previously placed tourniquet via a closed-loop mechanism or remotely operated by a medical operator to achieve hemorrhage control.

Methods/Technical Approach: Controlled hemorrhages and tourniquets can be identified by the system through distinct features. By this a clearly defined area on the patient can be rapidly and regularly checked for fresh bleeding by a battery powered lightweight robotic arm system (Fig 1a). If necessary, the system triggers an alert to the medical operator or, in standalone mode, automatically tighten the tourniquet (Fig. 1b). A timed control closed loop mechanism — loosening the tourniquet followed by blood detection — allows automatic reassessment of the patient's condition. At the same time the medical operator's workload is reduced.

Localizing unknown bleeding is more challenging. Camera systems, whether AI-assisted or human-monitored, quickly reach their limits due to spatial and color distortion caused by camouflage clothing. Therefore, a compartmentalized blood-detection blanket (Fig. 2) provides additional reliability for both the system and the medical operator to initiate appropriate measures.

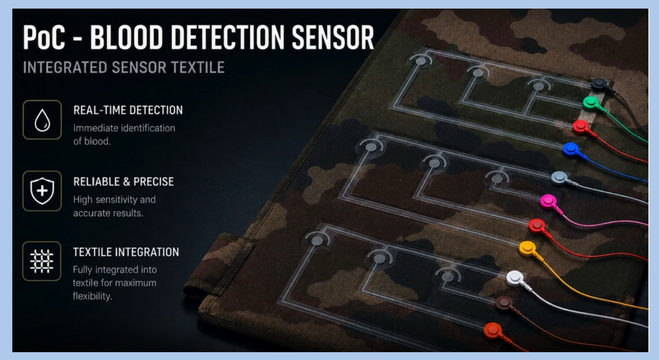

Fig. 2: 3 x 3 textile sensor pattern on a BDU tissue

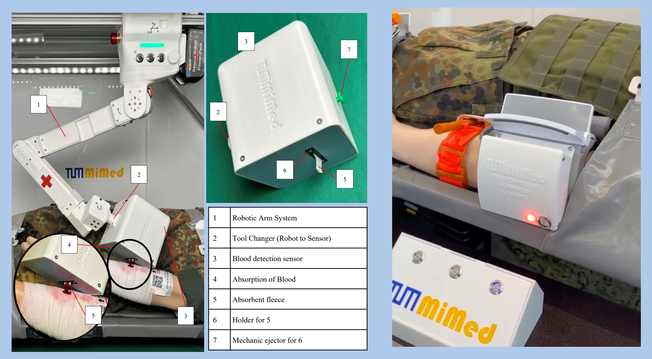

Fig. 1a: Robotic arm system with blood detection effector attached
Fig. 1b: Smart tourniquet attached to an artificial upper extremity

Applicability to Medical Roles of Care: The system is appropriate to be used during (autonomous) medical evacuations, in MASCAL scenarios or (non-)permanent casualty holding areas of medical treatment facilities.

Results: Two different means of detecting blood are being developed. A first approach using camera imaging and moisture detection and an electrochemical impedance spectroscopy to distinct reliable blood from sweat and water (Fig. 3).

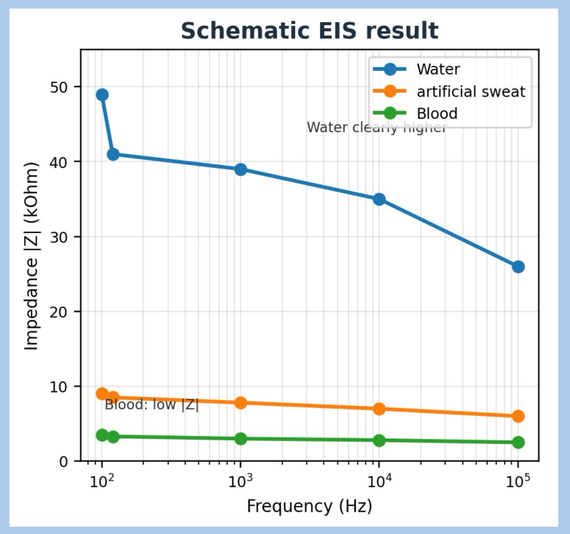

Fig. 3: differences of electro-chemical impedances detected by the textile sensor pattern

Impact to the Warfighter/ Significance: Automatic blood detection shortens the response time for stopping acute bleeding on an individual level, even in soldiers with impaired consciousness. It also helps monitor pressure dressings to detect secondary bleeding, facilitating the conversion of tourniquets and saving limbs.

Developmental Status of the Technology: The sensors described can reliably detect blood and distinct between sweat and water. The automatic application of the tourniquet works by a newly designed tourniquet based on electronic actuators. In future, some parts of the system can be miniaturized and integrated into smart textiles or bandages as the sensors can already be thermo-printed on tissues (Fig. 4).

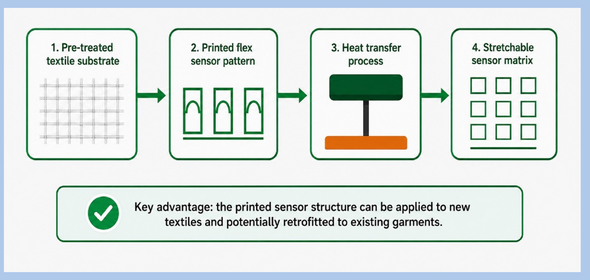

Fig. 4: Schematic illustration of the thermo-flexible transfer printing of the 3x3 sensor pattern

MHSRS 2026 3.-6. August 2026 Kissimmee, Florida, United States
Military Health System Research Symposium

E-Mail: christophwalterjaenig@bundeswehr.org

Grant Agreement No: 101121421
Funded by the European Union