Precision robotics for standardized wound cleaning

Uniform Wound Treatment with Sensor-Based Quality Control and Monitoring

Technology

The invention describes a robotic-assisted wound cleaning method in which a nozzle is guided precisely over the wound surface along a 3D model by a robotic arm. Sensors continuously assess the cleaning quality against a reference threshold. Whenever areas are found to be insufficiently cleaned, a closed-loop control automatically revisits those regions, adapting pressure, distance, and exposure time of the irrigation. Key features include targeted sub-area guidance, a constant impact angle within the laminar jet regime, and 3D geometry capture for model-based trajectory planning. Therapeutic agents can optionally be dosed into the irrigation fluid, fluorescently marked fluids may be used for subsequent quality testing, or abrasive particles can be added to generate mechanical-chemical effects. For users, this results in reproducible cleaning quality across the entire wound area, reduced operator dependency, potentially shorter treatment times via focused secondary cleaning, and objective quality verification through real-time metrics and storable reports.

Innovation

- Sensor-based, automated quality assessment.
- Closed-loop wound cleaning control with adaptive jet guidance and dosing for underserved regions.
- Multimodal sensor fusion (IR, HSI, electrical, chemical, MEMS) for robust quality metrics.
- 3D geometry-coupled sub-area strategy ensuring complete, uniform coverage.

Application

- Chronic wounds: Standardized debridement for diabetic ulcers, venous/arterial ulcers, pressure ulcers.
- Acute/traumatic wounds: Precise surface cleaning prior to definitive treatment, reduction in biological load
- Surgical preparation/revision: Standardized cleaning steps before graft/matrix application or suturing

Development Status

- Fully functional prototype: “Sense – Plan – Act” workflow, including kinesthetic sampling, target area modeling, visualization and path planning, transfer to standard robotic kinematics, and robotic execution

Responsible Scientist

Joint invention of

University of Freiburg und German Aerospace Center

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Medical Robotics, Water Jet Surgery

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