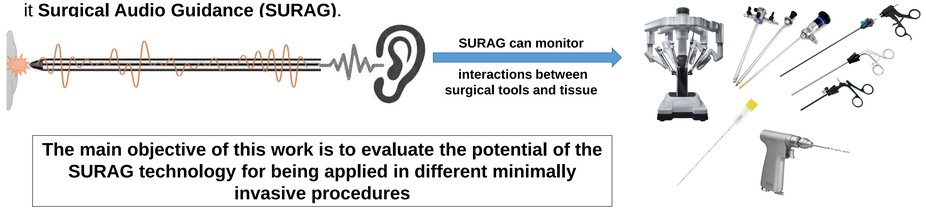
Surgical Audio Guidance: listening to interventional tools during medical procedures

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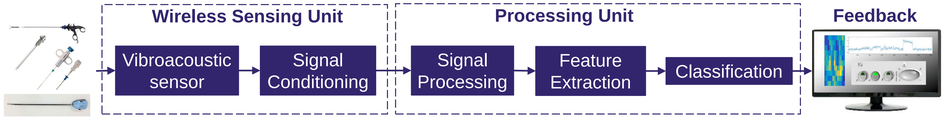
Objective

- When a surgical tool's tip enters in contact with tissue, a **vibroacoustic (VA)** wave is generated at the point of contact.
- This VA wave naturally propagates through the shaft of the instrument, **without the necessity of any active component** embedded in the shaft or tip of the instrument.
- This VA wave can be picked up from the proximal end of the instrument outside the body. This concept we call it **Surgical Audio Guidance (SURAG)**.



The main objective of this work is to evaluate the potential of the SURAG technology for being applied in different minimally invasive procedures

Description of technology

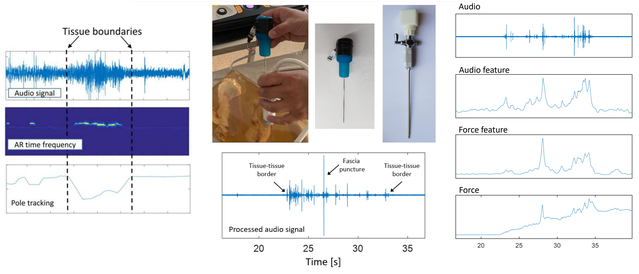


The SURAG technology involves three main components:

- The **sensing unit** involves the audio sensor attached to the tool and a signal conditioning step. It then sends the VA signal **wirelessly** to the processing unit.
- The **processing unit** extracts valuable information from the VA signal, related to tool-tissue interactions, using signal processing, feature engineering, and classification techniques.
- The extracted information is finally mapped into **visual and/or acoustic feedback** to the user.

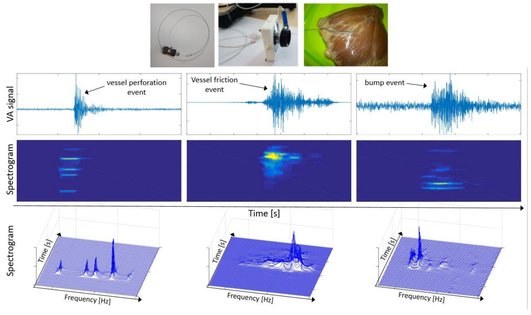
Preliminary results

SURAG for needle insertion into soft tissue

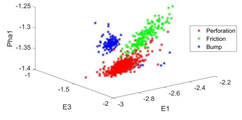


- Proof of concept using SURAG in biopsy and Veress needles.
- Resulting VA signals shows evident characteristics concerning important events occurring during needle insertion, such as:
  - Tissue boundaries
  - Puncture of important tissue layers as fascia
- VA sensing allows also accessing to information that force sensing provides.

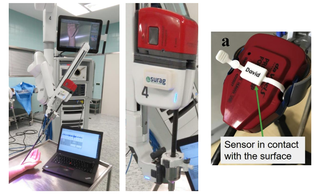
SURAG for identifying guidewire vessel perforation



- Proof of concept connecting SURAG at the proximal end of a guidewire.
- Resulting VA signal excitations involve specific time-frequency characteristics
- Different events occurring during guidewire insertion, such as bumps, friction, or vessel perforation appear with different and identifiable signal characteristics.
- Events can be classified using Machine Learning techniques.



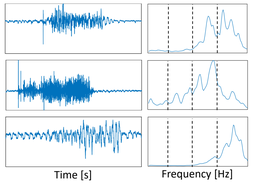
SURAG for monitoring robotic tool interactions





Experiments performed with sensors located at different positions (sterile and non-sterile zones) of a da Vinci instrument

Acquired VA signal excitations and resulting spectra for three type of tool interactions



- Interaction of robotic tools can be acquired with the SURAG VA sensing modality.
- The VA signal can be enhanced and processed for differentiation between different types of tool interactions

Conclusions

- SURAG is a novel modality for extracting surgical relevant information from tissue-tool interactions.
- Interactions starting at the tip of a medical instrument can be picked up and detected on the proximal end of a standard instrument
- It utilizes a yet unexploited source of information by acquiring, modifying and amplifying natural vibrations of the tool with a sensor attached to its proximal end without significantly altering the existing tool, setup and surgical workflow.

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