Electrical, Computer & Energy Engineering
UNIVERSITY OF COLORADO **BOULDER**

Ultrasonic Dissector with Enhanced Connectivity and Intelligence

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Medtronic

CUTTING EDGE

Introduction

Problem statement:

- Medtronic's Advanced Surgical Instruments Division has a need for real time sensor and image data to study surgical user technique and evaluate system performance and life.
- Presently the cordless Sonicision ultrasonic platform requires a wired connection to extract this data and impedes the mobility of this product.
- The jaw liner of the Sonicision devices can get damaged when in contact with blade without tissue, and there is a need to identify and provide early warning.
- The battery percentage of the Sonicision device is not explicitly displayed on the user Audio / LED interface - only Low Battery indication

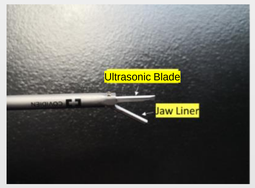

Figure 1: Ultrasonic blade and jaw liner of Sonicision device.

The previous system includes:

- Handheld device called Sonicision, which uses a generator to move a vibrating saw blade back and forth at ultrasonic speeds to cut tissue and seal vessels.
- Two PCB boards (inner & outer breakout board) attached to the device to collect data related to the device, such as voltage, current, power, friction, etc, through a USB cable.
- A data acquisition board (DAQ) used to collect data from other Medtronic devices.
- A graphic user interface (GUI) on Windows system to replay the recorded video from DAQ board.

Objective

To fix the problems mentioned above, our improved version of the system has:

- **Bluetooth Low Energy:** Wireless communication across devices to enable monitoring of devices set up.
- A **computer vision machine learning** algorithm that recognizes whether the ultrasonic blade and jaw liner is open or closed.
- A developed **Graphical User Interface** that can function in the operating room that allows for the display of a warning message when an ultrasonic blade is in contact with the jaw liner, preventing the device from getting damaged and ensuring longevity of these devices.
- A **phone app** that allows hospital personnel who manage medical equipment to check the battery percentage in between operations, and on-site troubleshooting to be performed by field technicians.

System Diagram and Setup

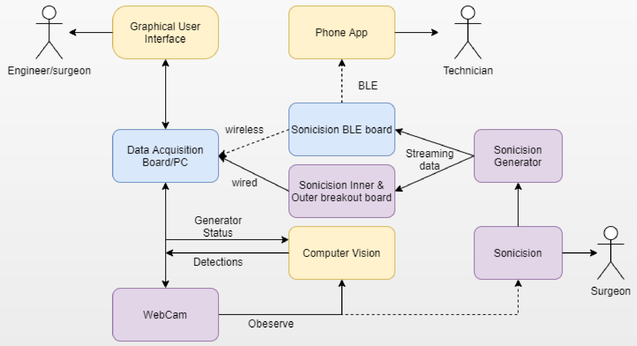

Figure 2: System diagram.

Components

- Sonicision: the handheld medical device that cuts and seals vessels.
- Sonicision generator: the brain and control, has the data that we would like to collect.
- Sonicision BLE: collects and transmits data.
- DAQ: Data Acquisition board
- Antenna: allows for a wide communication range.
- Webcam: pointed at Sonicision to detect jaw closure.
- Coral USB: performs high-speed ML inferencing.
- Embedded screen: a LVDS touch screen used to display the GUI.

During an operation, the surgeon uses the Sonicision and the monitor will output a audio and visual warning if the device is activated and closes without tissue in between. While the device is on, the SonicisionBLE sends data via bluetooth to the phone app and DAQ, allowing data to be collected and information to be viewed.

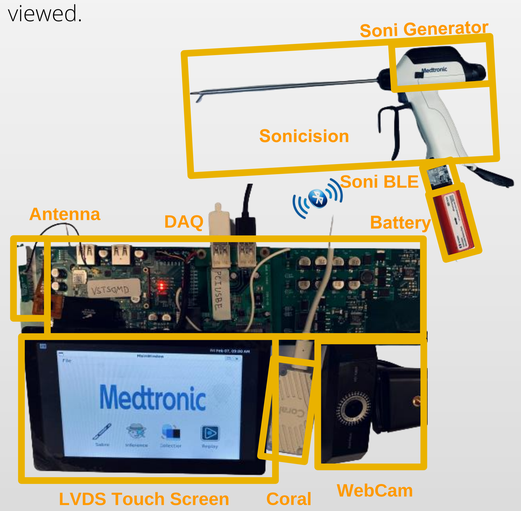

Figure 3: System setup.

GUI

The GUI integrates everything together, bluetooth, computer vision, sonicision data plotting and video-data sync.

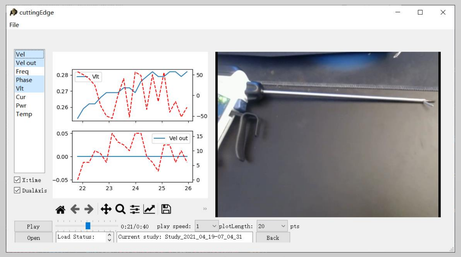

Figure 4: GUI plotting data in replay mode.

For the inference mode, a warning box appears when a closed jaw is detected for more than 1 second when the device is activated.

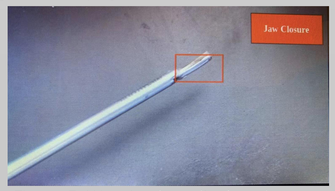

Figure 5: Warning box displayed on monitor when Sonicision closes.

Hardware

The hardware that was designed or modified in this project include the SonicisionBLE and DAQ board.

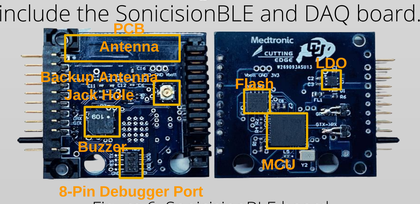

Figure 6: SonicisionBLE board.

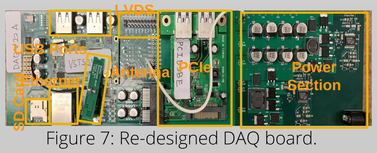

Figure 7: Re-designed DAQ board.

The SonicisionBLE is designed to replace the inner & outer breakout board used to wirelessly debug the ultrasonic dissector. The DAQ was re-designed to include a LVDS port to allow for the connection to a monitor and an antenna to improve the stability of bluetooth connection.

Conclusion

The main components of this project has been implemented with success.

Bluetooth:

- Connection is stable within 20 feet.
- Is able to transmit ultrasonic state variable data from generator to a phone as well as the DAQ.

Computer vision:

- The model can detect open and closed jaw liner and blade with over 80% accuracy.
- Inferencing time is less than 33ms on the DAQ system with everything else integrated.

GUI

- Capable of running all four modes: bluetooth, collection, inference, and replay.
- Collect streaming data and video simultaneously.

Next Steps

The completion of this project allows for a great potential for future development.

- The phone application will be a great platform for other functionalities
- Enhance machine learning:
  - 1) make computer vision model to be more robust that can detect damage with material between jaw and jaw liner (loaded situation).
  - 2) Microcontroller-fridenly machine learning inference and data-based neural network on SonicisionBLE since now Sonicision generator data can be collected.

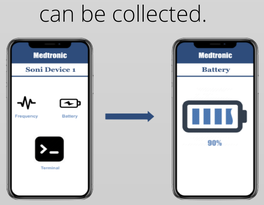

Figure 8: Phone app interface.

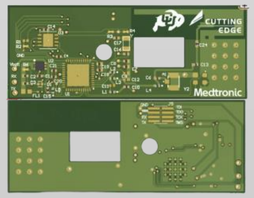

Figure 9: SoniBLE under generator

- BLE Board beneath generator. Move the current Sonicision board to the area beneath the Sonicision Generator board. Schematic and layout have already been made.

Acknowledgements

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