Wirelessly Powered Left Ventricular Assist Device (LVAD)

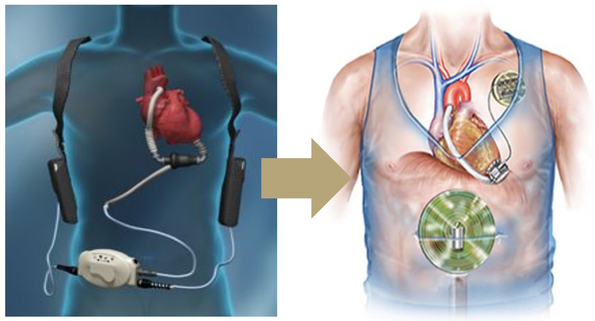
Cloe K. Lee, Thaolam T Ngo, Tin-tin Patana-anake. Faculty mentor: Joshua Smith

WIBOTIC

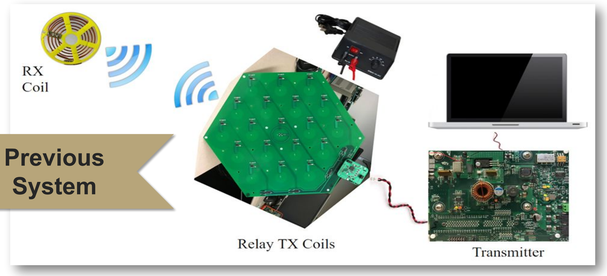
ELECTRICAL ENGINEERING
UNIVERSITY of WASHINGTON

INTRODUCTION

What is LVAD? an implanted mechanic pump that is attached to the heart and supports patience whose hearts are failed to pump enough blood to meet body's needs.



Problem:
- Powered through a wire inserted into patient bodies, which
- increases the risk of getting infection dues to exposed wire
- Medical cost due to monthly maintenance.



Previous System

Previous System :
- No wireless communication
- No User Interface
- Difficult to control coils and transmitter

CONCLUSION

Our system has showed that it is possible to integrate full operational wirelessly powered LVAD with the new Wibotic transmitter.

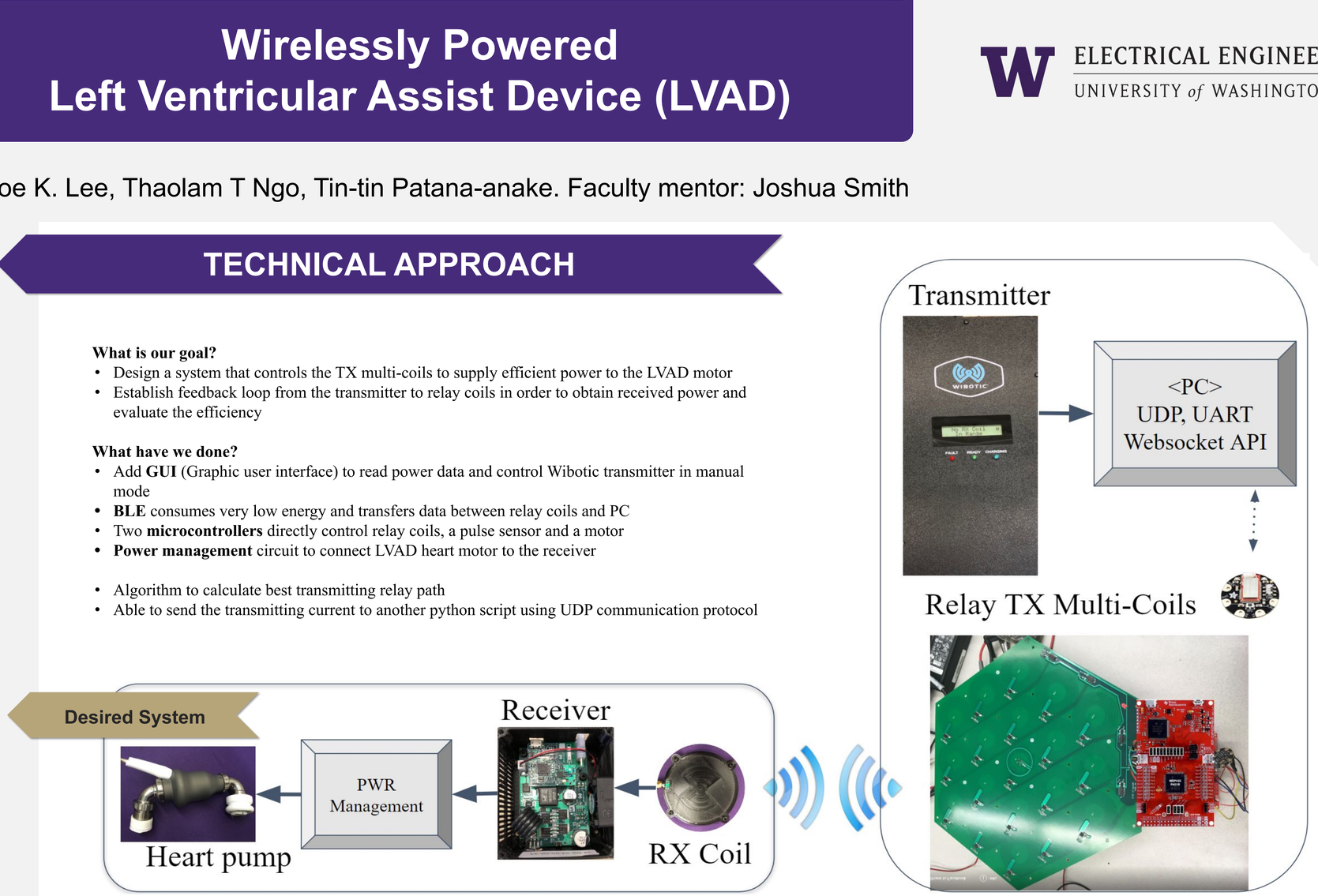
Future Aims
- Increase transmission range from the coil
- Wider operating range (currently will operate if the receiver is within a few centimeters of the operating range)
- Smaller receiver to be integrated with heart pump
- Modify the transmitter for low power application

TECHNICAL APPROACH

What is our goal?
- Design a system that controls the TX multi-coils to supply efficient power to the LVAD motor
- Establish feedback loop from the transmitter to relay coils in order to obtain received power and evaluate the efficiency

What have we done?
- Add **GUI** (Graphic user interface) to read power data and control Wibotic transmitter in manual mode
- **BLE** consumes very low energy and transfers data between relay coils and PC
- Two **microcontrollers** directly control relay coils, a pulse sensor and a motor
- **Power management** circuit to connect LVAD heart motor to the receiver

- Algorithm to calculate best transmitting relay path
- Able to send the transmitting current to another python script using UDP communication protocol



RESULT

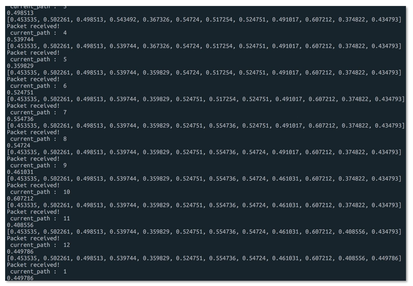


Figure 1: Transmitted current of each path

- Read transmitted current data from each path

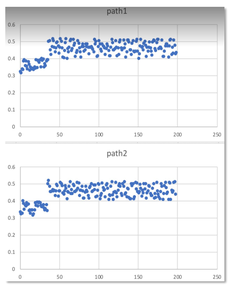


Figure 2: TX current of path 1 with LED (a), TX current of path 2 without LED (b) at power level of 60,000 (4V)

- When the LED is held close to the TX coils, the TX current expect to increase.
- Due to the manufacture process, these paths are not ideal

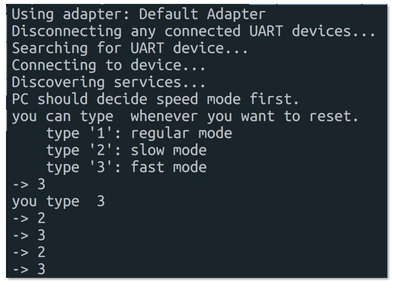


Figure 3: Relay TX coils controller

- Control speed of coil sweep and change mode
- Algorithm to decide the best relay path
- Simple wireless communication interface

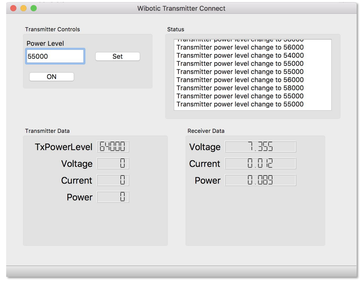


Figure 4: GUI (Graphic user interface)

- Control on/off states of the transmitter
- Allow adjustable power level with specific safety limit
- Show transmitter and receiver data
- Interact directly with Wibotic transmitter in the background

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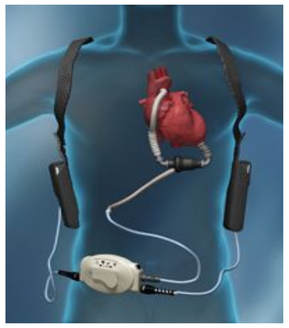
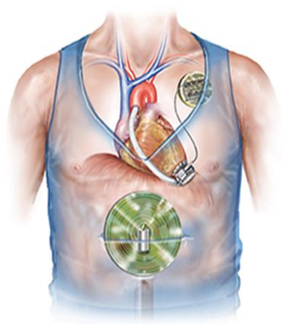
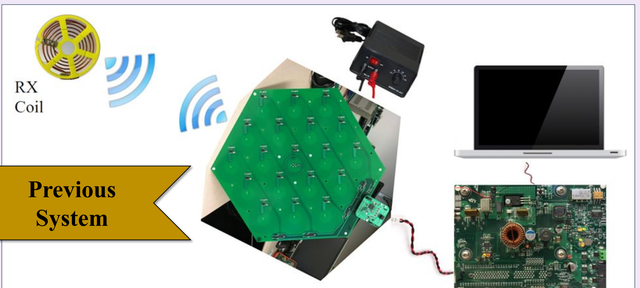
What is it? Left Ventricular Assist Device (LVAD) is an implanted mechanic pump that attached to the heart and supports patience whose hearts are failed to pump enough blood to meet body's needs.

Problem: Currently, LVAD is powered by an external source through a wire inserted into patient bodies, which can increase the risk of getting infection dues to exposed wire, and medical cost due to monthly maintenance.

Importance: Therefore, it is important for us as engineers to design a wireless power system to improve current system and make medical devices more reliable.







Previous System

OBJECTIVE

The new model of Wibotic transmitter and receiver provide access to amount of power that the receiver is getting. However, the its purpose is to charge battery and it has not been integrated with the LVAD. Our challenge is to design a system that controls this wireless transmitter to supply efficient power to the LVAD motor.

Hardware:

- Establish feedback loop from the transmitter to relay coils in order to locate the position of the receiver
- Manufacture circuit to connect LVAD heart motor to the receiver

Software:

- Algorithm to calculate best transmitting relay path
- Algorithm to control Wibotic transmitter in manual mode
- Graphic user interface for Wibotic transmitter

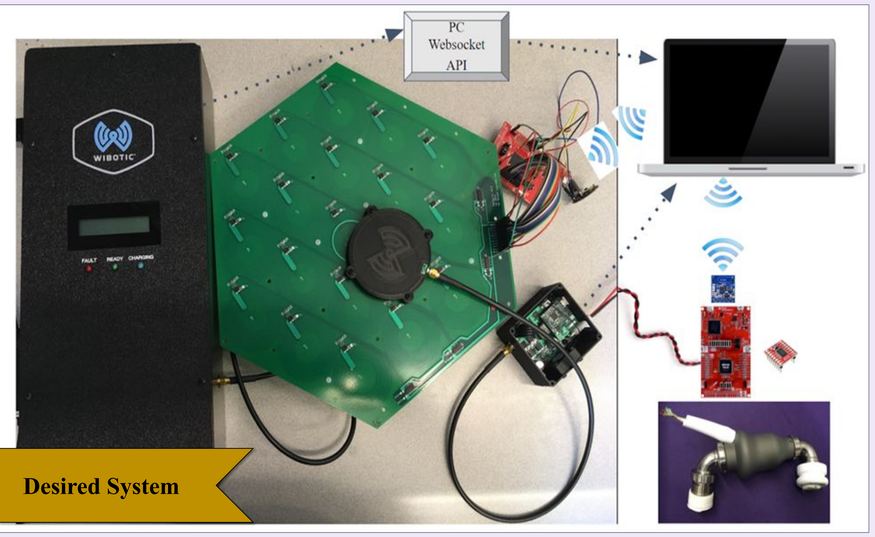
TECHNICAL APPROACH

Hardware:

- Transmitter is connected to computer via Ethernet cable to transfer data
- TX-coil receiver amplified power from the transmitter (up-to 125W) via SMA Cable
- Receiver
- RX-coil
- Operating Frequency is 13.56MHz ± 7kHz with system efficiency of 75%
- BLE
- Microcontroller

Software/Firmware:

- User Interface (PyQt5)
- Used UDP communication protocol to read the received current and send it to
- BLE technology is used to control
- Wibotic Transmitter Firmware that allows programmable control and seamless monitoring of battery charging.

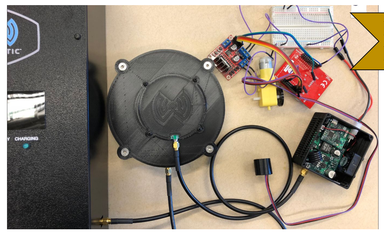


Desired System

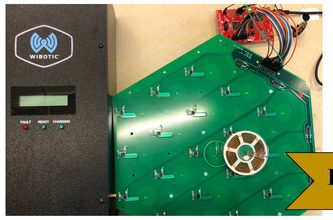
RESULT

The transmitter is capable of transmitter high power, however, with a limited range. The range is proportional to the size of the magnetic coil. Our algorithm is able to locate the receiver and able to choose path that would maximize power efficiency.

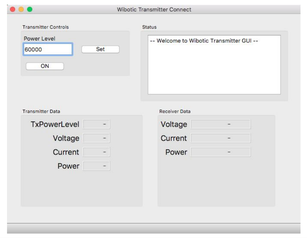
- Able to locate the location of receiver by reading the current transmitted by the transmitter
- Amount of power transmitted does not increase the transmission range
- To increase range, size of the magnetic coil must increase
- The receiver required approximately 3 watts to operate and require load to regulate rectified voltage
- Wibotic transmitter can be controlled in manual mode with Python script. Overcome black box model through trial and error to figure out successful algorithm.
- Able to demonstrate proof of concept of powering LVAD motor with the new Wibotic transmitter and receiver.



Motor Driver Module



Location



CONCLUSION

The transmitter provided by Wibotic is designed for high power application (50W) while the TX multi-coils can only withstand 10W. Therefore, when trying to supply