

# MRI-Compatible Skull-Embedded Implant for Direct Medicine Delivery

**Final Presentation: May 6, 2021**

**EN.601.456 Computer Integrated Surgery II**

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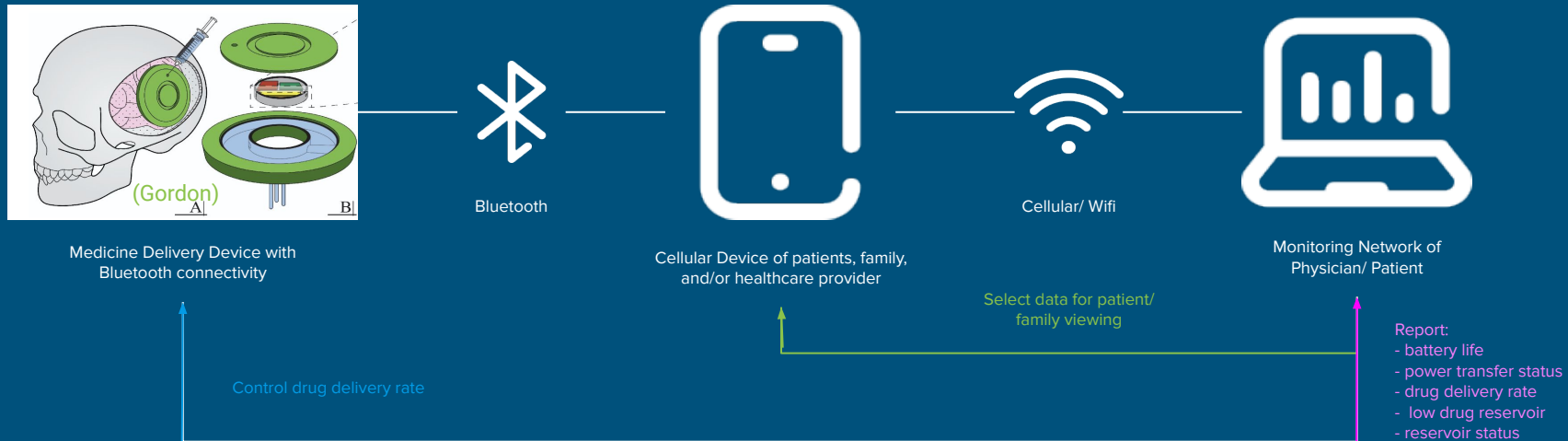
**Project Supervisor:** Tushar Jois



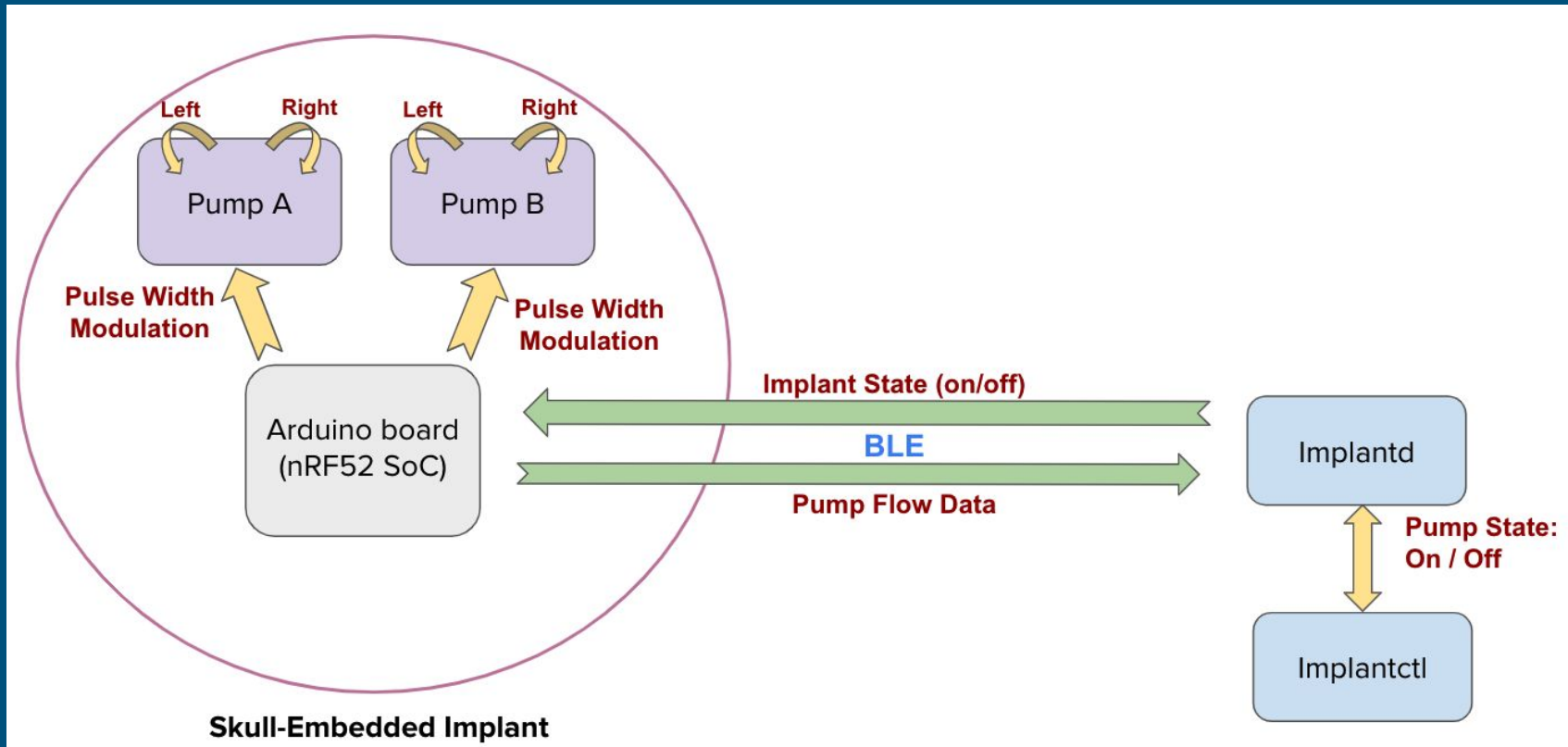
Center for Neuroplastic Surgery Research

# Our Goal

1. Implement code to use information from sensing pins to perform flow rate calculations every minute
2. Implement code to use Bluetooth Low Energy (BLE) to: (1) transmit flow rate estimates to clinicians and (2) send signals to turn implant pumps on and off



# Technical Approach



# Testing

## Pump Functionality **Verification**

Test	Date Completed	Pass / Fail
Pump switches directions at max iterations	03/25	Pass
Pump switches directions at min threshold	03/25	Pass
Pumps A and B function independently of each other	04/01	Pass
No action when both pumps turned off	04/01	Pass
Performs flow rate calculation at expected intervals	04/05	Pass

## Bluetooth Low Energy Connection **Verification**

Test	Date Completed	Pass / Fail
BLE Peripheral Connection	04/05	Pass
Turn LED on/off	04/12	Pass
Turn Pumps A and B on/off	04/12	Pass
Receives pump A rate at expected intervals over BLE	04/27	Pass
Receives pump B rate at expected intervals over BLE	04/27	Pass
Correct behavior upon BLE Peripheral disconnection	04/27	Pass

**Validation:** Feedback from project mentors on the clinical usability of the current implementation, integrate into current implant prototype for future swine studies.

# Completed Items

	Activity	Target Date	Actual Completion Date
Minimum	Implement code that only allows one pin to be active at one time in Runtime	3/3	3/5
	Set-up two analog “sensing” pins and supporting code to sense empty state of the pump	3/11	3/15
	Implement code to record signal detections from pins and time between direction reversals	3/25	4/05
Expected	Implement code to use information from sensing pins, to perform flow rate calculations every minute	4/07	4/20
	Implement code to use BLE to: 1) transmit flow rate estimates to clinicians, 2) receive signals to turn the pumps on and off	4/21	4/30
Maximum	Implement code that allows implant to receive and update to new target flow rate numbers given by clinician	5/01	Not Yet Completed
	Employ low energy secure connections: patient privacy	5/13	Not Yet Completed

Major Setbacks

Major Progress

# Next Steps

- Upcoming iterations of swine studies in Summer/Fall 2021
  - Implement phase 3: Implant can receive new target flow rate values from user and modify pump settings to alter delivery, low energy secure connections for patient privacy
- Rigorous assessment of pump performance and BLE connection
  - Testing flow rates more accurately: flow meter
  - Observe power consumption to estimate implant lifespan before battery recharge/replacement is necessary
  - Observe received signal strength indication (RSSI) score and % of successful BLE advertisements at varying distances



# Questions?





# Appendix





# Reference List

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- [1] Hottinger AF, Stupp R, Homicsko K. Standards of care and novel approaches in the management of glioblastoma multiforme. Chin J Cancer. 2014 Jan;33(1):32-9. doi: 10.5732/cjc.013.10207. PMID: 24384238; PMCID: PMC3905088.
- [2] Solid lipid nanoparticles for skin and drug delivery: Methods of preparation and characterization techniques and applications - ScienceDirect: <https://www.sciencedirect.com/science/article/pii/B9780128162002000153>
- [3] Gordon, Chad. *Magnetic Resonance Imaging Compatible, Convection-Enhanced Delivery Cranial Implant Devices and Related Methods*. CraniUS®, 2020.

# Weekly Meetings and Management Plan

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## Meetings:

- Weekly Neuroplastic Surgery Laboratory meetings on Monday 10AM
- Weekly meetings with Tushar: TBD, likely Wednesday 10AM
- Biweekly meetings for group: Monday 9PM, Thursday 10AM

## Programs Used:

- Communication using Email and Slack
- Sharing code using GitHub
- Writing Reports and Documentation and Uploading onto CIS Wiki

Work was divided equally, but the following lists specific code contributions:

- Henry: Flow rate calculations and BLE peripheral set up
- Disha: Pump loop, pump sensing and BLE peripheral set up
- Vivian: Pump direction switches, setting up test plans