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Portable Cardiac Stimulator For Electrophysiological Studies

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Abstract

Electrophysiological Studies (EPS) are used to characterize the function of a heart. Currently, researchers use dated cardiac stimulators for EPS, that are inaccessible, bulky, and difficult to use. We aim to replicate and improve the functionality of the cardiac stimulator currently used at Children's National Hospital with a microcontroller as a more cost effective and intuitive alternative in order to replace the antiquated system.

Background

- A variety of cardiac stimulators are used to conduct EPS.
- **Bloom DTU-215B** : Model currently used by Children's National (Fig. 1)
- **Micropace ORLab™**: Current State-of-the-Art (Fig. 2)

Figure 1: Bloom DTU-215B Model

Existing models are ***expensive***, ***large***, and ***complicated***, so we aim to replace them utilizing accessible and ubiquitous materials

Fig 2: Micropace ORLab ™

Methods

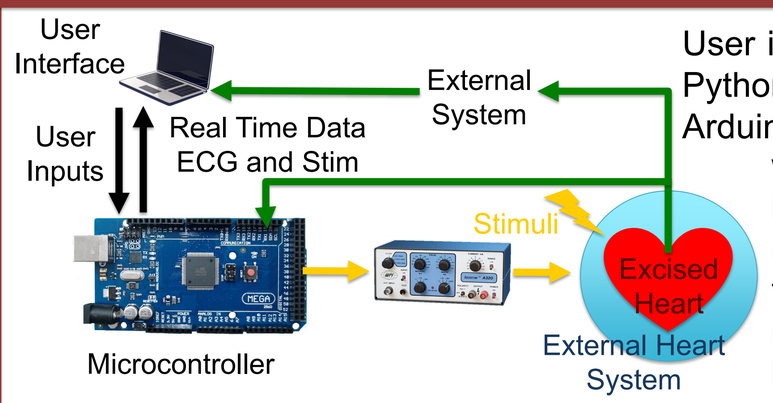

Figure 3: Schematic describing the system and flow of information, including as ECG and Stimulus data

User interface developed with Python in communication with Arduino Mega, programmed with Arduino system. Interfaces with stimulus isolator to send pulses to the heart. ECG data returns to the interface both through Arduino and from external system for verification

Objectives

We aim to use a microcontroller to create a ***inexpensive***, ***portable***, and ***intuitive*** device that can be used to conduct electrophysiological studies. It must be compatible with software and hardware used at Children's National Hospital and perform all necessary functions to conduct animal studies more efficiently and accurately than the current Bloom Cardiac Stimulator.

Results

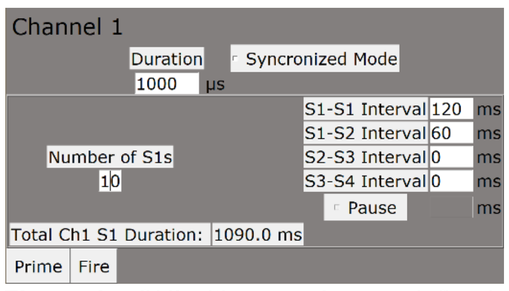

Figure 4a: GUI with example user defined settings entered.

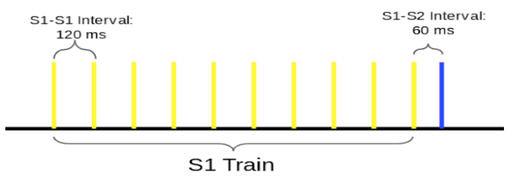

Figure 4b: Expected corresponding stimuli

These images were obtained during an animal study conducted at Children's National Hospital. User defined parameters were set in the GUI to emit 1000µs long stimuli at an interval of 120ms, then an additional stimulus at 60ms as shown in Figure 4a. Based on the set parameters, it is expected that graphically the stimulus would look as depicted in Figure 4b. A screenshot of the live plot on the user interface, shown in Figure 5, was obtained and compared to the ECG results produced using the current IOX2 software from emka TECHNOLOGIES to assess accuracy, shown in Figure 6. Throughout experimentation it was found that our device had a minimum interval of capture at 30ms.

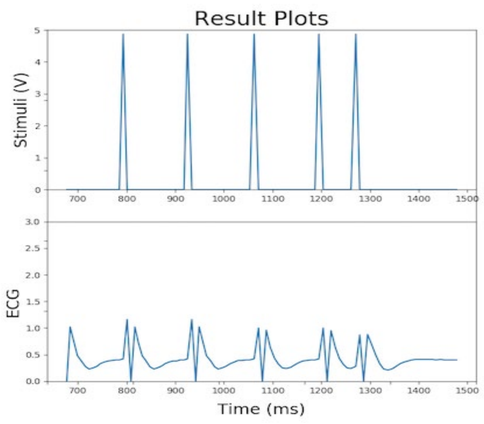

Figure 5: Screenshot of live plotting of stimuli and ECG on user interface.

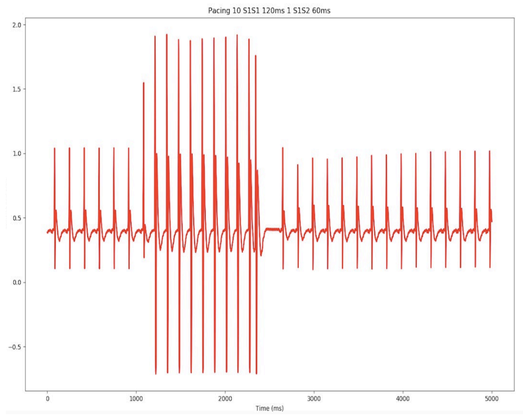

Figure 6: Based on the ECG results, we can verify that the stimuli was successful in pacing the heart.

Conclusions

- Through an analysis chart (Tab. 1), it was determined that our device was successful in improving upon existing technology in the three critical fields addressed.
- Additionally, our cardiac stimulator experimentally showed a minimum interval of capture at 30 ms, an improvement upon the Bloom's 50 ms.**
- Device is not only comparable to the Bloom, but in some ways it is an improvement

Model	Cost	Size	Usability
Bloom	$1000+*	~11 kg	Difficult
ORLab	$45000+	5.3 kg	Difficult
Ours	<$50	0.037 kg	Easy

Table 1: Comparison between devices in three fields

*used, **limited experimental testing

Ethical Implications

Intellectual Property

- Open-source and Accessible Materials
- Guide to developing this device will be made publicly available
- Promotes collaborative research in the field, leading to the development of new technologies

Ethical Implications

- Device is not inherently dangerous, but is a prototype and not approved for clinical uses
- Thorough disclaimers are needed to prevent misuse

Future Work

Improvements upon the developed cardiac stimulator include increasing the display rate of the live plot, including multiple channels, and developing wireless Bluetooth capabilities. The ultimate goal for this device is use in clinical settings, and the research described above has paved the way for such a device to exist.

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