N.I.C.O.L.A.S.
Oral Exam

January 22, 2020

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NI Non-invasive

C Continuous

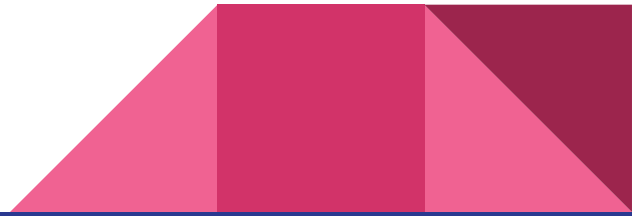
O Optical

LA Lactic Acid

S Sensor

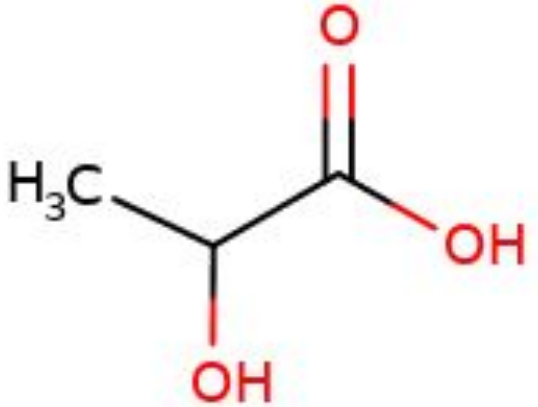
Overview

- Background
- Problem Statement
- Needs Assessment
- Project Plan
- Design Components
- Future Design Path



Background

- Clinical biomarker used to measure tissue degradation
- Causes of increased lactate levels
  - Sepsis
    - Organ injury/damage in response to infection
  - Hemorrhage
  - Organ Failure
    - Increase in lactate dehydrogenase
- Normal levels ~ 1 mM.
  - Relative > Absolute measurements



Lactic Acid
(2-hydroxypropanoic acid)

Background


Sepsis
Organ Failure
Hemorrhage
lead
to
Lactate Level
Increases
lead
to
Morbidity and
Mortality

Problem Statement

- Currently, blood is drawn too infrequently to detect rapid spikes in lactate levels, which indicate the onset of life-threatening complications, such as:
  - Septic shock
  - Organ failure
  - Hemorrhage

Needs Assessment

Patient

Insulated Device
Intermittent Pulses
Non-invasive

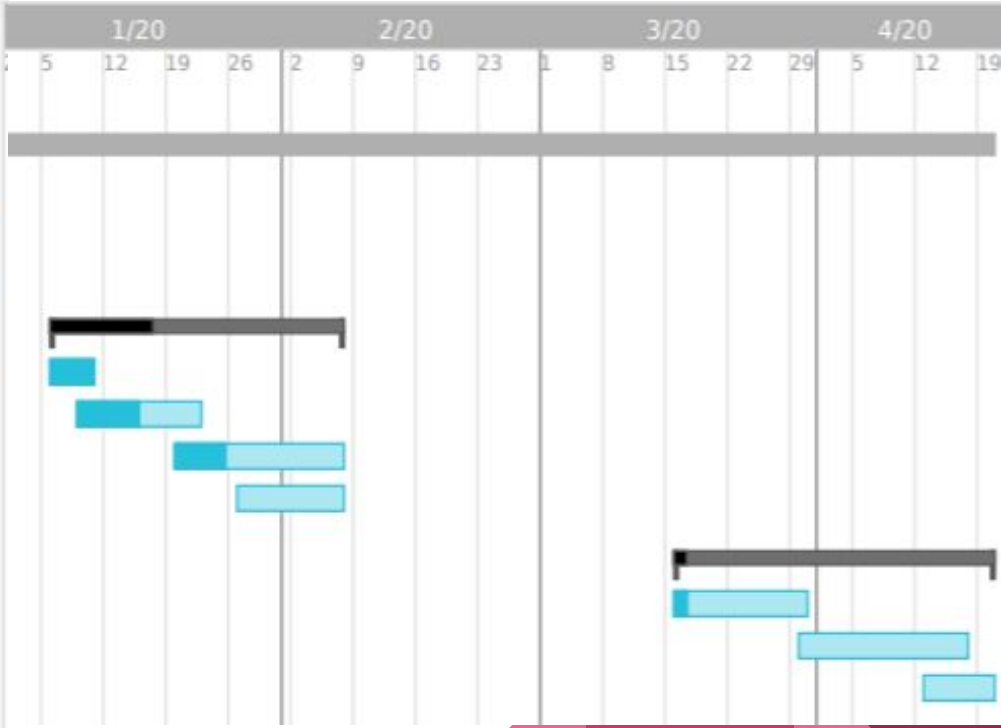
Practitioner

Continuous Sampling
Ease of Use
Clinical Application

System

Simplest Modality
Vascular Accessibility
Cost Effective & Portable
Integrate with Hospital Systems

NICOLAS: Gantt Chart	**0h**	**44%**
First Steps	**0h**	**100%**
Ongoing Meetings and Updates	**0h**	**100%**
Prototyping, Design Validation	**0h**	**35%**
1st Iteration -- produce signal	0	100%
2nd Iteration -- consistent waveform	0	50%
Design of Finger Clip	0	30%
Lactate Sensing -- proof of concept	0	0%
Future Plans and Presentation	**0h**	**4%**
IRB Application	0	10%
Clinical Testing	0	0%
Design Day Preparation and Presenta...	0	0%

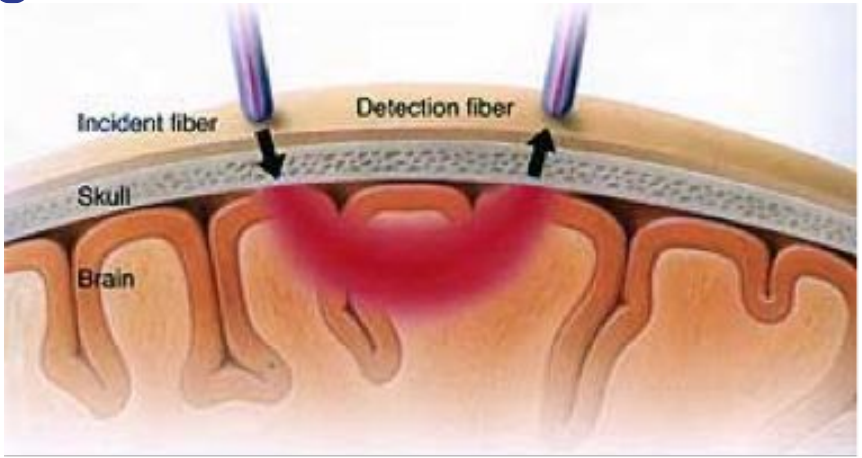


Proposed Solutions

- Indirect Electrochemical Measurements
  - Sweat -- difficult to obtain from certain patients
  - Saliva -- does not respond quickly to changes in the body
- Direct Electrochemical Measurements
  - Microdialysis -- constant blood drawing
  - Very invasive, potential for corrosion over time
- Optical Methods
  - Noninvasive
  - Quick response to physiological changes
  - Does not degrade

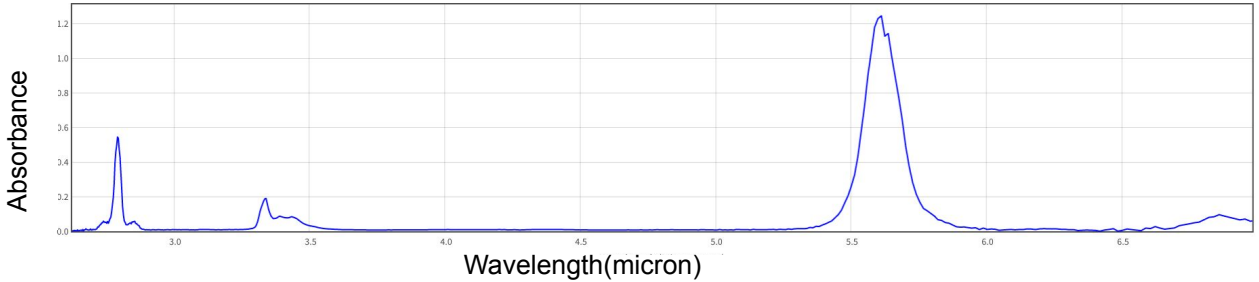
Proposed Optical Methods

- Raman Spectroscopy
  - Expensive, not portable
- IR Spectroscopy
  - Transmission
  - N.I.R.S.



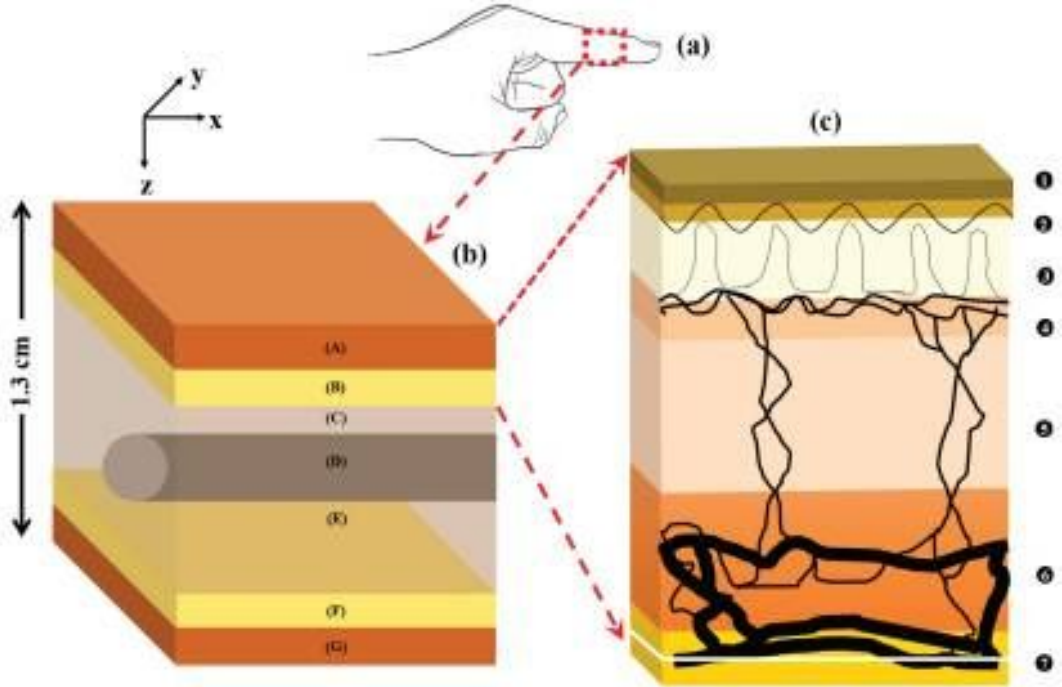
Near Infrared Spectroscopy (NIRS)

Lactic Acid Spectrum

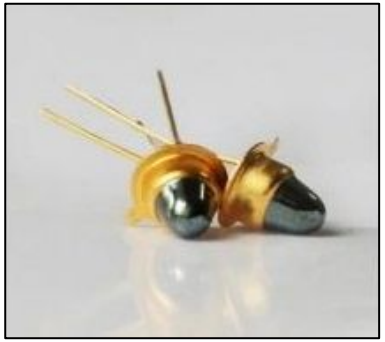


Optical Challenges

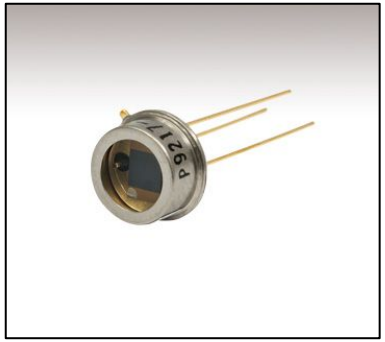
- The main concern is the optical penetration
- Penetration is determined by the absorbance of skin tissue
    - Different absorbances for epidermis, dermis, etc.



Design Components



https://www.gophotonics.com/



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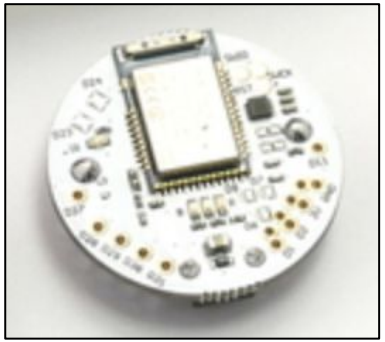
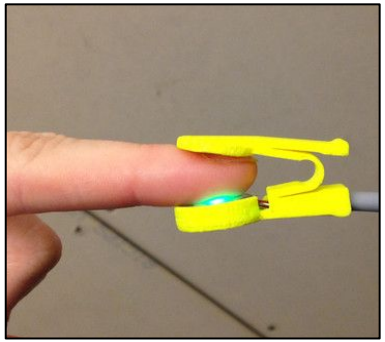


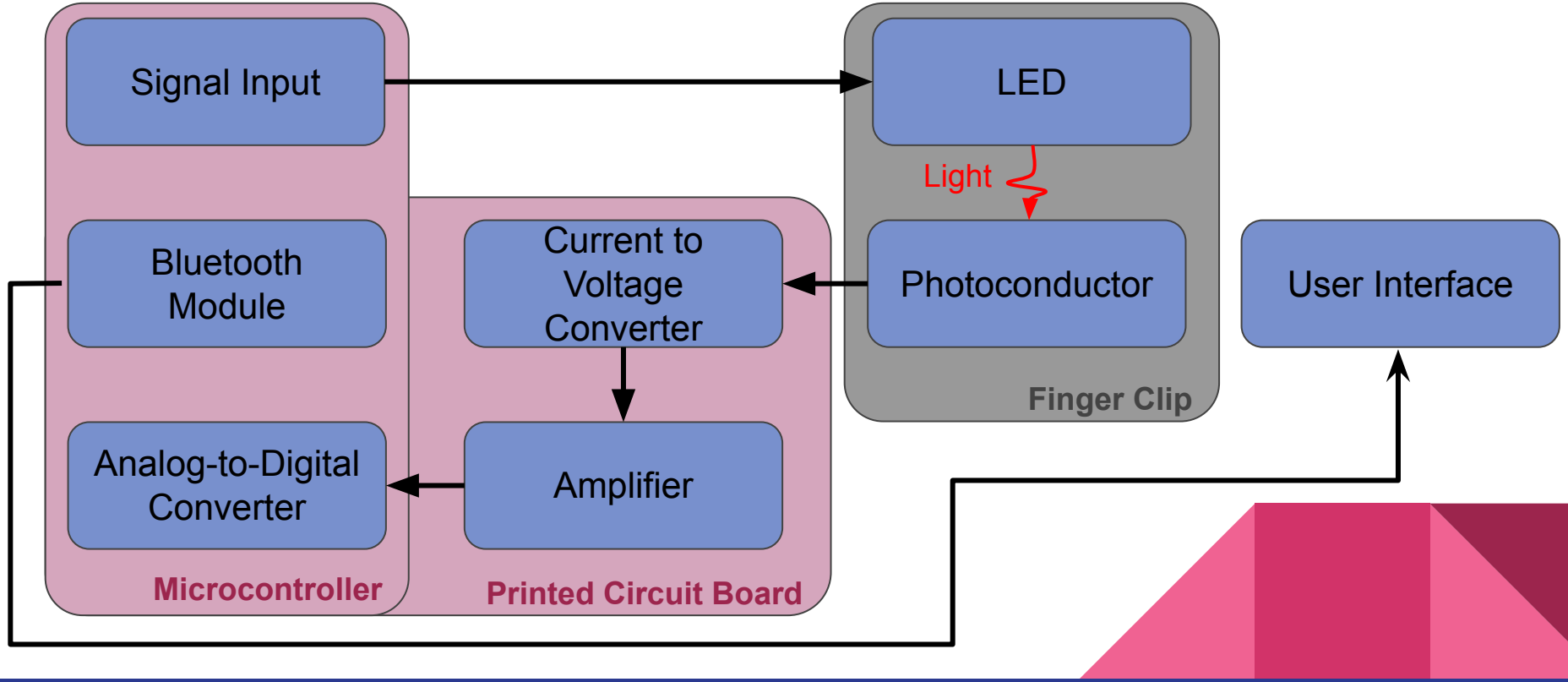
http://www.espruino.com/



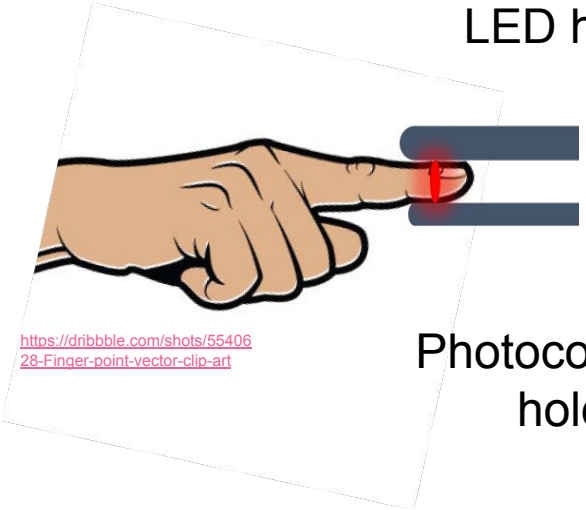
https://grabcad.com/library/

- LED and photoconductor integrated into bluetooth capable microcontroller
- 3D printed finger clip
- Battery operated

Block Diagram



Finger Clip Design



https://dribbble.com/shots/5540628-Finger-point-vector-clip-art

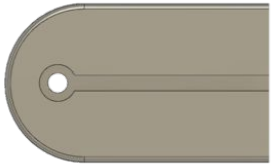
LED holder

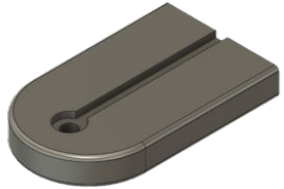
Photoconductor holder

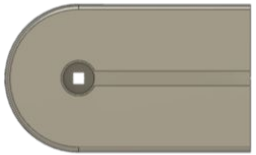
Bottom (finger facing)

Top

Isometric







Design Validation Studies

- Signal Amplification
- Lactate Absorbance Curve
- Phantoms
  - Account for hemoglobin, tissue thickness, blood heterogeneity, etc.
  - Sensitivity and Selectivity
- Finger Clip Optimization
  - Light directionality
  - Packaging

Future Directions

- Anticipated Packaging Constraints
  - May need to expand to a finger clip and wrist cuff system
- Finger Clip Fit
  - May need to adopt more complex clip geometry for better measurements
- Clamp Mechanism
  - Needs to be able to adopt to varying finger sizes
  - Needs to be secure on finger without being too tight
- Light Directionality
  - Need to optimize shape for light directionality

Materials to be Purchased

- Quartz Cuvettes: $72.50
  - Quartz vs Plastic absorption
- Lactic Acid: $47.50 (250mL of 90% L-lactate)
  - High purity solution
- Microcontroller: $13.00
  - Arduino micro
- Bluetooth module: $10.00
  - HC-05 transmitter