OPTIMIZING PREMATURE INFANT GLUCOSE BALANCE
via Continuous Glucose Monitoring and Control

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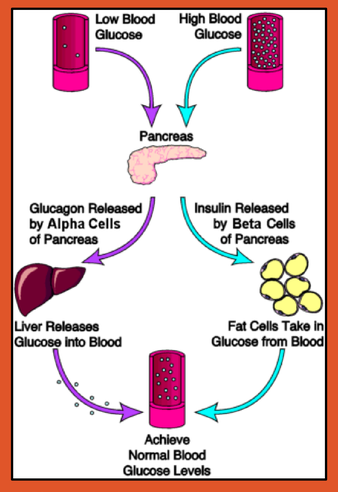
Low blood sugar (Hypoglycemia) is a dangerous condition in neonatal infants. A control loop using a continuous glucose monitor (CGM), Raspberry Pi, Arduino microcontroller, and syringe pump is proposed to automatically add additional glucose when low blood sugar is detected. This system will assist staff by relaying real time information to doctors and nurses allowing for on the spot medical decisions.

Preterm infants can be extremely small, with body volume low as 40 mL

http://infobaby.org/wp-content/uploads/833-4948808b5c0e93a9a74f1b687ab773b5b.jpg

ANATOMY AND PHYSIOLOGY

- *In utero* blood glucose is regulated by the mother; preterm infant physiology is not prepared to regulate glucose.
- Hypoglycemia (infant serum glucose level below 40 mg/dL) affects 5 to 15% of healthy babies and can cause seizure, brain damage, or death
- Hyperglycemia (infant serum glucose level above 150 mg/dL) can cause nerve damage, kidney failure, and death. It is usually a result of glucose infusions given to counter hypoglycemia.

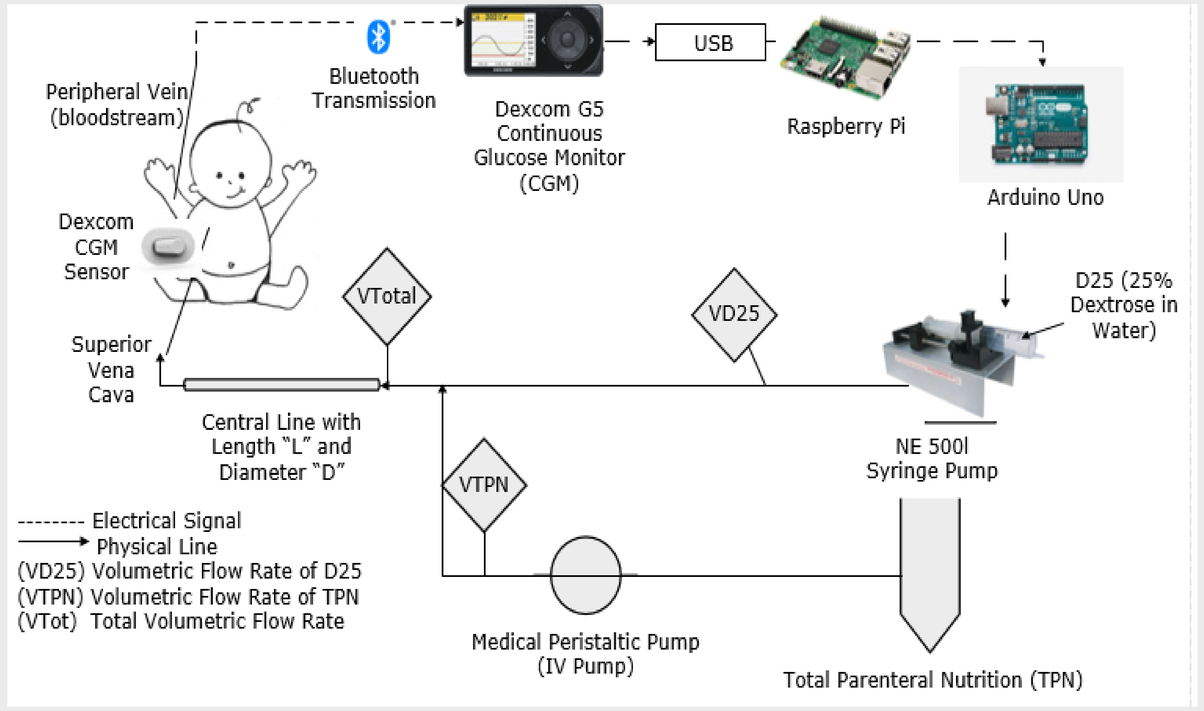


Normally processed Glucose in the Body. The glucose is processed in the Pancreas and then is regulated using glucagon and insulin.

www.endocrineweb.com/conditions/diabetes/normal-regulation-blood-glucose.

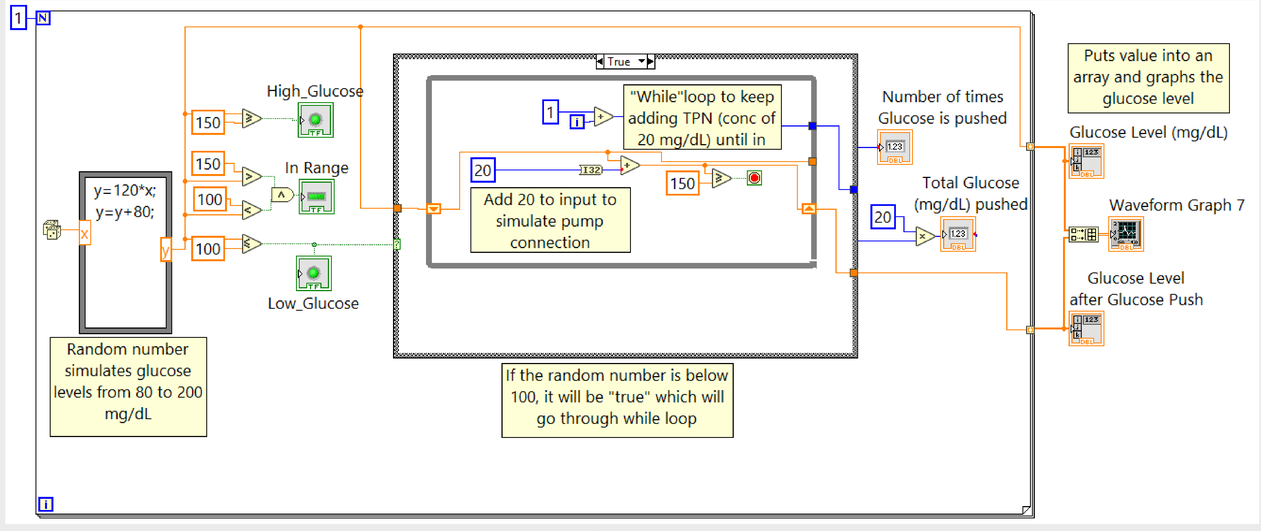
ISSUES & OPPORTUNITY

Current glucose control methods require manual monitoring and treatment by a nurse. This allows for larger error to accumulate as there is time delay in treatment. An automated system will allow for real-time information relay and tighter control as glucose can be titrated in real-time.



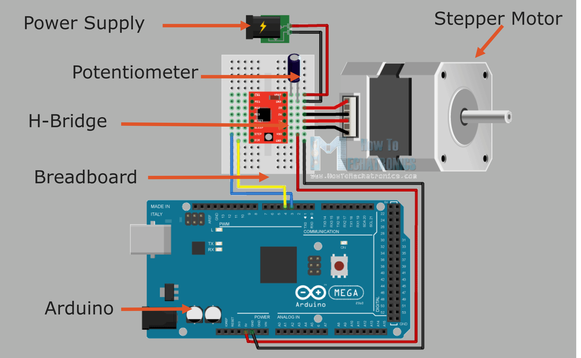
Process Flow Diagram. A Dexcom CGM Sensor measures the glucose level in an infant through a peripheral vein. Blood glucose data is sent to a CGM and outputted to a Raspberry Pi. The Pi ports the blood glucose data to an Arduino which evaluates the blood glucose level and determines how much (if any) glucose (D25) needs to be sent to the infant.

Images: Baby: http://big5kayakchallenge.com/wp-content/uploads/2018/01/unique-cartoon-baby-outline-how-to-draw-cartoon-baby-with-easy-drawing-lesson-for-kids-cartoon-baby-outline.png Dexcom G5: https://cdn3.volusion.com/htpcb.ckdza/v/vspfiles/photos/1919-2.jpg?1472735165 All other images obtained through Creative Commons Licenses.



LabVIEW Code. A random number generator is used to simulate changes in infant blood glucose levels. The number is evaluated in a logic loop that uses a *while loop* function to decide if glucose needs to be given to the infant. The current blood sugar and the amount of glucose given to the infant is displayed to allow for convenient monitoring by healthcare personnel.

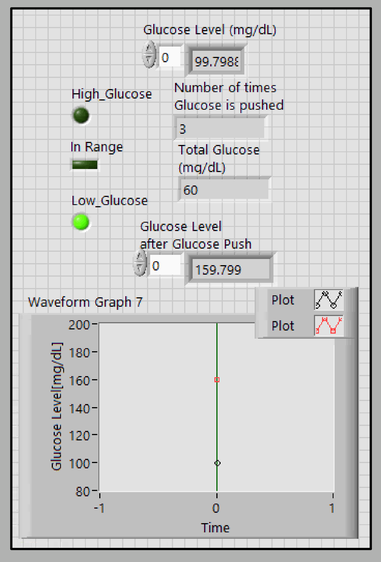
CONTROLLER SCHEMATIC



Stepper Motor Control Circuit. An Arduino Uno is used to control the bipolar stepper motor that drives the syringe pump by regulating voltage. A potentiometer controls the voltage level while the H-Bridge generates the signal needed for the pump to turn. The Arduino control code is programmed using C. https://howtomechatronics.com/wp-content/uploads/2015/08/Controlling-Stepper-Motor-Circuit-Schematics.png

FUTURE WORK

- Finish wiring the circuit to the stepper motor
- Work with Dexcom to connect the Continuous Glucose Monitor (CGM) to the Arduino.
- Write program in to port CGM data to control Arduino
- Develop Graphical User Interface (GUI) hosted on Raspberry Pi (similar to figure below).



LabVIEW Front Panel. An example of the display for health workers. An LED light indicates glucose level (high, controlled, low) for, "at a glance," data. A graph gives a plot of glucose levels over time. The amount of glucose solution given to the infant is displayed.

ACKNOWLEDGEMENTS

- OSU TekBots Lab for assisting the team with the circuit work.
- Andy Brickman for advice on electronics and signals.
- Dr. Adam Higgins and Dr. David Dallas for sponsoring this project
- Anna-Liisa Sepp for kick-starting this project and her continual help.
- Dr. Phil Harding for feedback and weekly advice

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