IV LEVEL INDICATOR

BMEn 3151 Medical Device Practicum

Authors: Khai Dang, Caleb Van Leeuwen, Sadhika Prabhu, Jared Snidarich

CLINICAL PROBLEM

Alarms from IV smart pumps sound when the IV fluid level crossed a threshold. This one out of many alarm types nurses might "tune-out", when it came to responding to the alarm (1). Additionally, the overwhelming number of alarms setting in at the same time can be hard for nurses to keep track of. According to one nurse, only one commercial syringe infusion pump does not have an alarm. When IV fluid was not replaced on time (i.e. could be up to every 4 hours), the patient could be in danger. The IV smart pump's system of warning nurses through alarm is not efficient. Especially, all alarm types of smart pump might sounds the same; And, troubleshooting alarm might require experience for new-income nurses. When the alarm sounds, nurses need instantaneous information on how to troubleshoot the alarm, which they then can move on to other tasks. Alarm from IV smart pump for IV fluid level is important, but the way of conveying information on IV fluid level could be more efficient and effective.

NEEDS STATEMENT

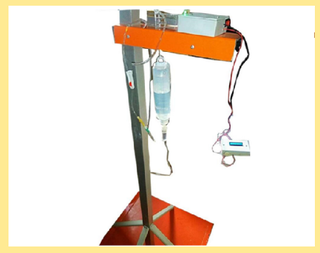
Hospital staff need a way to have a distinguishable indication of the IV bag level that is non-disruptive because constant and frequent alarms are disruptive and unhelpful to patients and hospital staff. This would reduce the stress of the hospital staff and the patients by allowing for a longer reaction time window to address the low IV bag level.

MARKET ANALYSIS

Some load-cell based options already exist on the market for IV bag early warning systems, but our product is unique in reducing alarm fatigue and making visibility easier for quick identification of fluid level.

LoadStar IV Monitoring Cloud-based Data

Can contribute to information overload when dealing with multiple patients/bags



Automated Infusion Monitoring System

Still gives audible alarms, transmits to central location such as nurses station which is already high-traffic, busy area.

MEDICAL DEVICE SOLUTION

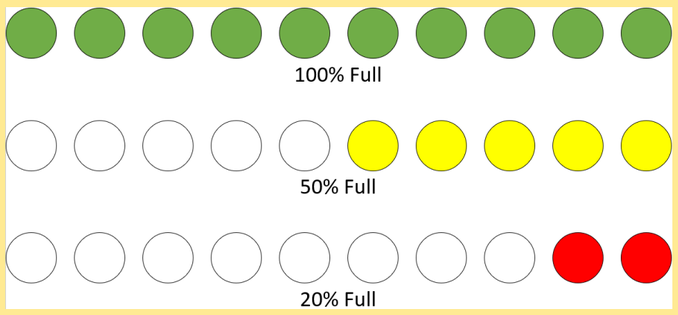
Liquid level sensor:

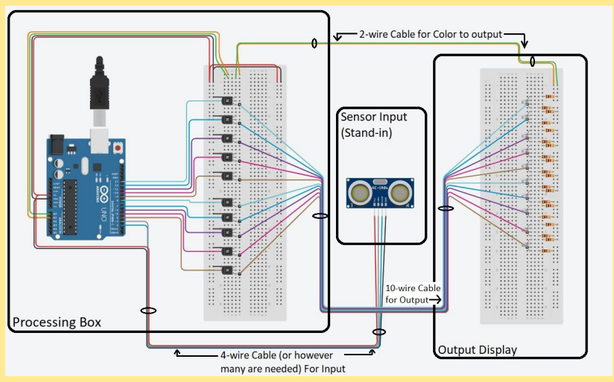
A capacitive type sensor is used which can detect liquids without being in contact with them (health safety). It is a digital type on/off sensor that senses if the liquid is present above the set level and outputs with a Red/Green LED for quick reference.
Mechanically, the liquid level sensor is attached to a plastic clamp bracket that clamps onto the top of the IV bag. The vertical placement of the sensor can be changed to create a "setpoint" detection level and accommodate different IV bag sizes. The plastic model is put together with nuts and bolts.

Weight level sensor:

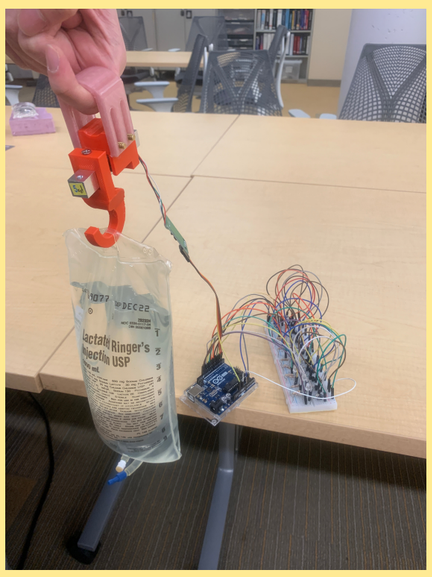
The system is made up of the Arduino, HX711, one load cell, the PLA model, LED, wires, nuts, and bolts. Increased load on the load cell causes a deflection and change in resistance, and the change in voltage is amplified by HX711. The load cell voltage is sampled at 2 Hz to give a near-constant analog reading for estimated weight. This value is managed by the Arduino to output a different number and color of LED lights for quick visibility of percent full.
Mechanically, the plastic hook pulls the top of the load cell downward, while the plastic bracket and body pull the bottom of the load cell upward. The bracket can adjust its height to accommodate the size of the IV bag's hook. Nuts and bolts hold load cell, plastic hook, plastic body, and plastic bracket together.

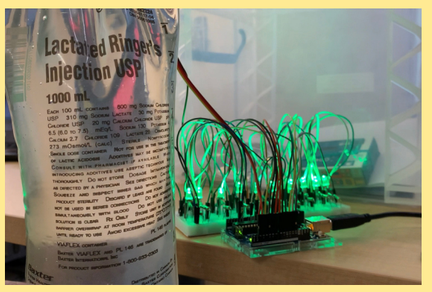
Electronic System Matic

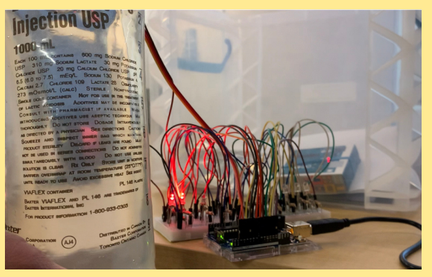




Mechanic System







FUTURE THOUGHTS

The conversation on improving the efficiency and effectiveness of communication between nurses and technology is encouraged. Especially during the pandemic, nurses could be overwhelmed by the information, while feeling exhausted. Ideas for the future include ways to delegate specific alarm type to specific nurses (i.e. registered nurses have more authorized control over some medical technology than assistance nurses), to communicate the alarm information to any nurses in the building (i.e. nurses might be out of the hearing range of the alarm), and to digitally and personally keeping track of their own tasks (i.e. by tracking the tasks in a system rather than memory, there might be less chance to forget about the task). Further study is encourage on alarm fatigue, and the all ideas above. For the project, the future improvement includes incorporating sensor into the mechanical design, manufacturing aspects of the design with aluminum or plastic, design an integrated LED circuit board, and helpfulness of our design in making nurses' job easier.

LITERATURE AND ACKNOWLEDGMENTS

(1). Alarm Fatique: Evidence and Management Strategies. Youtube, March 2017. Maria Cvach, Bradford D. Winters.
(2). Peripheral intravenous (IV) device management. The Royal Children's Hospital Melbourne.

Acknowledgement

1. Nurses that participated in the interviewed.
2. Prof. Steven Saliterman (VentureWellTM Faculty Grant recipient, member of the Department of BME at UMN)