**Objective**

HP is interested in developing a microfluidic sensor with the capability to efficiently and inexpensively characterize and sort particles suspended in solution. The sensor will distinguish between particles based on size and composition and integrate with a mobile interface, such as a smartphone or tablet, to provide access to complex lab services on the go.

**The Need**

- **Healthcare:** Point of care diagnostics such as HIV/AIDS (CD4+)
  - Ensuring Fuel Quality
  - Determining hydraulic oil particle contamination in machinery

**Our Vision**

- **Lightweight and portable**
- **Low cost (less than $500)**
- **Automated, no training required**
- **Powered with phone or tablet**
- **Requires small sample (<1 drop)**
- **Integration with HP Cloud Services**

**Current Technology in Cell Detection**

- **Capabilities**
  - Reliably counts cells (4-25 µm)
  - Provides cell size distribution
- **Limitations**
  - High cost ($3000-$20,000)
  - Single-purpose device
  - Requires trained technicians
  - Often requires fully prepared samples

**What is Impedance?**

- Simple Circuit
  - w/applied voltage
  - Ideal circuit analysis can only measure real resistance

- Complex Circuit
  - Cellular Model
  - Actual circuits incorporate the real resistance and non-real resistance contributions from inductors and capacitors

**Impedance Cytometry**

- Different frequencies will probe different components of a cell, allowing characterization of the cell membrane and cytoplasm.
- Detecting certain cell populations can be accomplished by comparing high frequency and low frequency impedance signals.

**Test System**

**Impedance Chip**

- Left: Early development impedance sensor
- Bottom Left: Magnification of the bottom side of an ink-jet print nozzle implanted with an impedance sensor. Latex beads in a phosphate buffer solution will migrate toward the air interface at the center of the nozzle.
- Bottom Right: The impedance sensor applies a voltage across the electrodes which creates an electric field within the channel. Beads cross the electrodes and disturb the electric field, which causes a spike in impedance.

**Signal Processing and Analysis**

- **Input**
  - Noisy raw data with changing baseline
- **MATLAB**
  - Creates a moving average fit
  - Finds minima points and creates a baseline function
  - Normalizes data by subtracting baseline function from moving average
  - Correlates peaks to physical properties such as size, velocity, and composition
- **Output**
  - Quantifiable data
  - Particle counting possible with user designated threshold

**Design Recommendations and Future Work**

- Propose improved circuit design with optimal voltage and frequency settings
- Implement a network of sensing channels to sort particles on-chip
- Replace the current triangular geometry of the sensing channel with a symmetrical sensing volume that utilizes two identical electrodes
- Develop a predictive mathematical model
- Update the mobile application as the functionality of the sensor increases

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**References**