Functional Prototype Description

Sequence of Events

1. Insertion of catheter into the urethra
2. Inflate balloon until certain volume is reached using a syringe
3. Manual adjustment to get estimated region of boundary (i.e. boundary is located between the two sensors on the balloon) where the two sensors give different readings
4. Mechanical refinement of the position such that active sensor (one of the two stiffness sensors selected) is aligned, as closely as possible, with the location of the boundary
5. Detection of the surgical tool relative to the boundary location detected

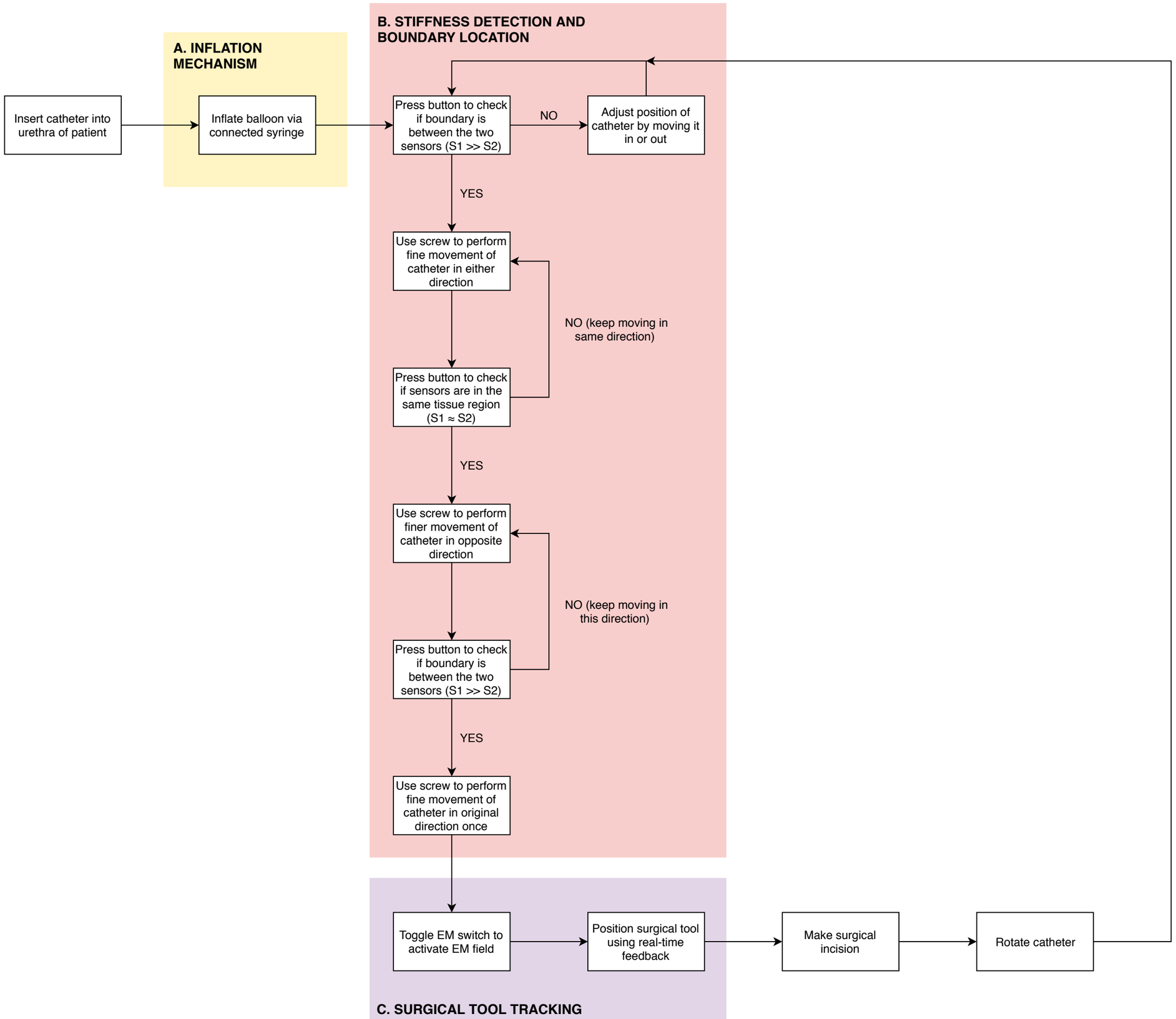
Decomposition

The device can be split into three main parts:

A. Balloon inflation
   - **Input:** Syringe
   - **Output:** /
   - **Process:** /

B. Stiffness measurement and boundary detection
   - **Input:** Button to measure stiffness from two sensors, stiffness sensors (2)
   - **Output:** light to indicate that boundary is between the two sensors, light to indicate that two sensors are in the same tissue region
   - **Process:** Comparison of stiffness signals from each sensor to toggle lights
   - Implemented using analog circuit components

C. Surgical tool positioning
   - **Input:** EM sensors (3), switch to activate EM field on surgical tool, switch to turn on EM sensors on catheter
   - **Output:** Display or lights to show proximity or relative position between the surgical tool and the boundary
   - **Process:** Detection of position of the EM source and calculation of proximity to toggle display/indication
   - Implemented using an Arduino micro-controller


A. INFLATION MECHANISM
B. STIFFNESS DETECTION AND BOUNDARY LOCATION
C. SURGICAL TOOL TRACKING
Insert catheter into urethra of patient
Inflate balloon via connected syringe
Press button to check if boundary is between the two sensors (S1 >> S2)
NO
Adjust position of catheter by moving it in or out
YES
Use screw to perform fine movement of catheter in either direction
NO (keep moving in same direction)
Press button to check if sensors are in the same tissue region (S1 ≈ S2)
YES
Use screw to perform finer movement of catheter in opposite direction
NO (keep moving in this direction)
Press button to check if boundary is between the two sensors (S1 >> S2)
YES
Use screw to perform fine movement of catheter in original direction once
Toggle EM switch to activate EM field
Position surgical tool using real-time feedback
Make surgical incision
Rotate catheter