

## Clinical Problem

- Intensive care unit (ICU) patients rely heavily on **critical medical devices** (e.g., endotracheal tubes, intravenous lines, catheters, feeding tubes).
- Agitation, anxiety, delirium, and the inability to communicate can lead patients to remove these devices (i.e., **self-extubation**).
  - Leads to serious **complications** (e.g., vocal cord trauma, hypoxemia, respiratory arrest, arrhythmia [1]).
  - Re-intubation is necessary in 40–60% of cases, often doubling ICU stay and up to \$25,000 in added costs [2].

## Existing Solutions

Methods	Definitions	Limitations
<b>Physical Restraints</b>	Mechanical devices or materials that limit patient movement	<ul style="list-style-type: none"> <li>Patient agitation</li> <li>Mental stress</li> <li>Physical injury</li> </ul>
<b>Mechanical Stabilization Devices</b>	Bandages, wraps, or tube holders to secure tubing or limit hand access	<ul style="list-style-type: none"> <li>Skin irritation [3]</li> <li>Patient discomfort</li> <li>Fails to fully prevent removal</li> </ul>
<b>Sedation (Chemical Restraints)</b>	Medication used to reduce patient agitation and prevent tube removal	<ul style="list-style-type: none"> <li>Increased risk of delirium</li> <li>Longer ventilation times</li> <li>Long-term cognitive impairment [4]</li> </ul>



## Our Solution

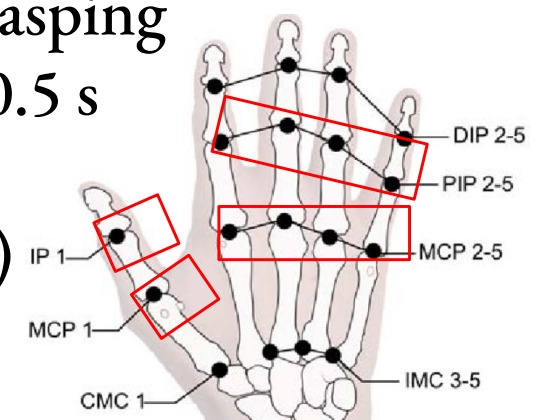
**Objective:** Building upon a previous team's two-camera detection system, we aim to integrate an **inflatable glove** that prevents grasping motions *only* near **critical tubes** or lines.

- Prevent grasping while inflated but allow full hand motion while inactive/deflated
- Reduce self-extubation and dislodgement to improve patient and staff experiences

## Criteria for Success

### Must Have:

- Reliable activation only near critical tubing
- Inflates to ~5" diameter to impede grasping
- Ensure device activation occurs in < 0.5 s
- Sized to fit average adult hand (~7")
- Restrict metacarpophalangeal (MCP) and interphalangeal (IP) joints [5]

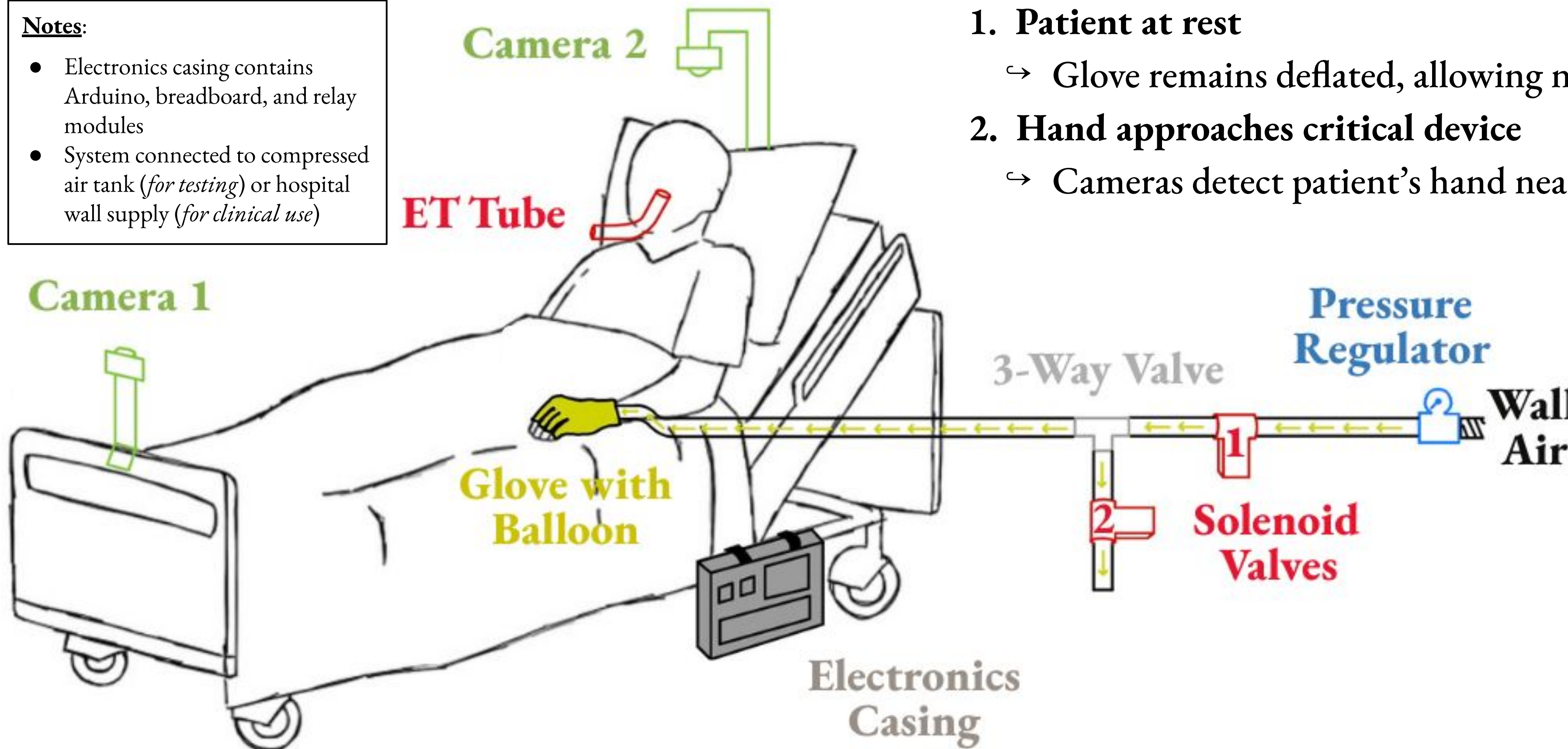


### Nice to Have:

- Reusable, sterilizable tubing
- User-friendly setup for staff
- Comfortable material for extended wear
- Compliance with medical device standards

## Methods

- Notes:**
- Electronics casing contains Arduino, breadboard, and relay modules
  - System connected to compressed air tank (for testing) or hospital wall supply (for clinical use)



### 1. Patient at rest

→ Glove remains deflated, allowing normal hand movement.

### 2. Hand approaches critical device

→ Cameras detect patient's hand near tubing or other medical devices.

### 3. Glove activates

→ Solenoid 1 opens, inflating the glove in ~0.5 s.

### 4. System reevaluates after 20 s

→ Cameras check whether the hand is still near the critical device.

### 5. Glove deactivates

→ If the hand is clear, Solenoid 2 opens and the glove deflates.

## Testing Results

- Circuit system** inflated bladder in ~0.5 s under 20 psi; increasing pressure caused issues with valve leakage and pressure buildup.
- Bladder** in pocket can **passively** deflate due to elastic materials; deflation is slower than inflation.
- Code** makes it so that after solenoid opens and inflates, it stays closed for ~20 s before system **reevaluation**.
- Hand** has to be **directly** over green dot in the camera system for solenoid system to activate.



## Ethical Considerations

### Patients:

- (+): ↑ allowed mobility, ↓ self-extubation, ↓ need for restraints/sedation
- (-): Limits some autonomy and real-time consent, possible discomfort

### Healthcare Providers:

- (+): ↑ response time, ↓ monitoring burden, ↓ emergency re-intubation
- (-): False activations, potential workflow disruption

### Hospitals/Healthcare Systems:

- (+): ↓ complications and costs, ↑ patient safety
- (-): Risk of device misuse or failure, environmental impact

## Future Improvements

- Reduce** activation time to ~10 ms to outpace human reaction time
- Improve** detection accuracy (increase marker specificity)
- Upgrade** materials for durability and repeated use
- Expand** to multiple glove sizes for broader use
- Design** circuitry to enable dual-hand detection and control

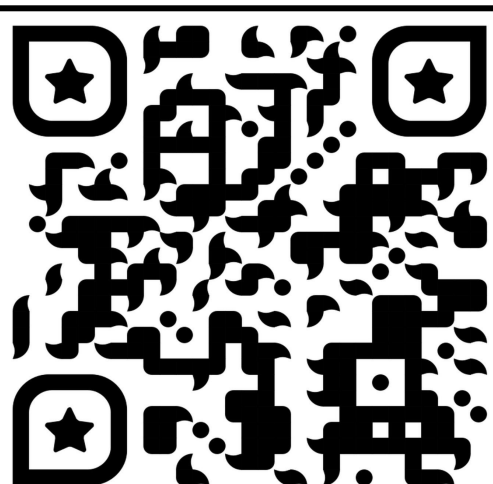
## Conclusion

**Summary:** Our proximity-activated inflatable glove system offers a **feasible, less restrictive approach** to reducing self-extubation in the ICU.

- Preserves patient autonomy and comfort → potential to reduce reliance on traditional restraints and sedation, improving clinical outcomes.

## Acknowledgments

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References