

## **Patent Application: Robotic Diagnostic and Venipuncture Systems with Advanced Tactile and Visual Integration**

**Title:** Systems and Methods for Robotic Diagnostics and Guided Venipuncture Utilizing Tactile and Visual Technologies

**Field of Invention:** This invention pertains to robotic systems integrating tactile sensing, visual imaging, and machine learning to enable precision diagnostics and vascular access. The invention applies specifically to guided venipuncture and separate robotic systems for non-invasive diagnostic procedures for breast cancer and prostate evaluations.

**Background:** Medical technologies for venipuncture, breast cancer detection, and prostate exams often lack the integration of tactile feedback and visual data, limiting precision and patient comfort. While ultrasound (US) and near-infrared (NIR) imaging are commonly used for vein localization, manual palpation remains the standard for complex cases. Similarly, breast and prostate exams rely heavily on clinician expertise, leading to variable accuracy and patient discomfort. This invention addresses these gaps by introducing three specialized robotic systems, each leveraging advanced tactile sensing technologies.

**Summary of Invention:** The proposed invention consists of three distinct robotic systems that share a common foundation in tactile sensing technology:

### **1. Robotic Venipuncture System:**

- A dual robotic arm system integrating tactile sensors with US and NIR imaging for real-time vein localization, manipulation, and needle guidance.
- One robotic arm mimics human touch to locate, manipulate, and stabilize the vein into the ideal position, while the second arm precisely guides and inserts the needle.
- Designed to optimize vascular access by simulating human touch and dynamic adjustments.

### **2. Robotic Breast Diagnostic System:**

- A tactile-based robotic system to detect tissue irregularities, providing consistent and non-invasive breast cancer diagnostics.
- Capable of identifying anomalies through precise palpation and machine learning analysis.

### **3. Robotic Prostate Diagnostic System:**

- A system designed for prostate evaluations using tactile sensors to detect irregularities in gland size, texture, and elasticity.
- Offers a non-invasive alternative to traditional manual exams, enhancing patient comfort.

## **Detailed Description of Invention:**

### **1. Tactile Sensing Integration:**

- All three systems use tactile sensors capable of detecting tissue elasticity, depth, and texture changes.
- For venipuncture, the sensors mimic human palpation, enabling vein stabilization and manipulation. For breast and prostate diagnostics, the sensors provide detailed feedback for anomaly detection.

### **2. Visual Imaging for Venipuncture:**

- US and NIR imaging systems provide real-time visualization of veins for precise needle guidance.
- AI algorithms process visual and tactile data streams to dynamically adjust the robotic arm's movements.

### **3. System-Specific Design:**

- **Venipuncture System:** Features dual robotic arms—one for vein manipulation and another for needle insertion—integrated with Fresenius Kabi's Aurora plasmapheresis systems.
- **Breast Diagnostic System:** A standalone robotic arm with tactile sensors optimized for identifying tissue anomalies, providing consistent pressure and palpation patterns.
- **Prostate Diagnostic System:** A robotic platform designed to assess gland elasticity and size through non-invasive tactile analysis, enhancing accuracy and patient compliance.

### **4. AI and Data Processing:**

- Machine learning models trained on extensive datasets enable the systems to analyze tactile and, where applicable, visual inputs for real-time decision-making.
- Feedback loops ensure adaptive adjustments during procedures.

## **Claims:**