

# DESIGN OF 3D PRINTED NEEDLE INSERTION DEVICE AND CONTROL USING MOBILE PHONE APPLICATION

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## ABSTRACT

Breast cancer is a disease with significant worldwide impact. Many hand-operated biopsies have been performed by radiologists to diagnose patients with a cancerous lesion. Robotic systems have been developed and demonstrated an increased accuracy of biopsies. However, with the introduction of robotics, the radiologist's biopsy device is often replaced by a less-intuitive interface like a joystick. Furthermore, robotic biopsy systems are costly. This research proposes a design of a needle insertion device, which combines a rapid prototypeable end-effector with control using a hand-held smartphone.

Low-cost servo motors are used to generate rotational motions in two dimensions of freedom, plus a stepper motor used in a screw-thread mechanism for a translational injection of the needle. All components are assembled in a 3D printed enclosure. The system uses the built-in accelerometer and gyroscope sensor of the mobile phone to retrieve the phone's orientation, which is reproduced by the end-effector. A mobile application is designed to retrieve the phone's sensor data and communicate wireless to a microcontroller. In the system modes are implemented to increase the workability: in biopsy mode, the angular movements are attenuated to enhance precision.

Results show that the designed robot had an angular accuracy of 1.03 degrees based on targeting predefined points in space using an automated program. The phone's orientation was captured with less than 0.30 degrees deviation from the real orientation in all directions. The full system was tested by targeting lesions inside a transparent phantom with 85% success rate (17 hits out of 20 attempts). Using the robotic system developed in this research, it is possible to control an injection needle using a handheld mobile phone, and target lesions sized 1 cm and up to 9 cm deep with 85% success rate under visual guidance.