Autonomous Trocar Insertion Robot to Aid in Minimally Invasive Surgery

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A trocar is a device that creates ports in the abdominal wall to allow for laparoscopic and endoscopic surgeries. Trocar insertion has been associated with several surgical injuries due to surgeons' reliance on their limited haptic and visual feedback. Designing a robot capable of autonomously inserting trocars to any desired point on the patient will eliminate this risk. Using stereo sensors made from Raspberry Pi cameras, the robot can search for and triangulate the position of ArUco markers placed on the patient's body and dynamically track them throughout the surgical process. Camera calibration was performed to remove distortions within the images, creating more accurate estimations. The robot is able to estimate patient position with 0.3mm accuracy and autonomously travel to markers. Once within range, the robot will insert the trocar via a lead screw attached to a stepper motor. Once the trocar makes contact with the patient, force sensing is used to determine the insertion depth of the trocar into the abdominal wall, as there are discrete peaks and drops in force sensing data. To measure the force profile, the trocar was inserted into layers of plastic wrap, styrofoam, and paper. By measuring the velocity of the data, we can see large drops into negative velocities as the puncturing of each layer. Detecting and recording velocities of -0.1N/Sec, the robot is able to autonomously insert and stop once it has exited the material. All proving that a trocar can be inserted safely into the body by a robot.

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