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**Force Sensing in Medical Robotics**

**Background:**

The utilization of medical robotics started earlier in contrast to industrial robots that had an extended past dating back to 1960s. The increasing use of medical robotics is a result of a need for repeatable precision assisted by the recent achievements. Modern discoveries in the field help solve a number of complications by providing multiple variables at the surgical tool tip. Moreover, the surgeons became unable to perform some of the exact medical functions at the miniature level. However, it is no longer a problem because of the invention of various force sensing techniques which detect the actual problem at the miniature level and pass accurate information to the surgeon.

**Force Sensing Techniques in Medical Field:**

Various force sensing techniques are applicable in the medical field. A few of the majorly used force sensing techniques are outlined below, depicting the progress of these techniques in the medical field.

One of the force sensing techniques quantifies defects in an elastic object caused by applying force to the object. The employed sensor works on the fundamentals of displacement variations. The amount of force can also be determined as a function of measured deformity by using the physics of elastic properties of materials. Various sensors can be used to measure the precise amount of deformity in the elastic structure. These sensors include potentiometers, LVDT, digital encoders and optical fiber based sensors.

The devices including motor-actuated joints can quantify the applied force by computing the current of motors as the originated torques are proportional to the armature current of motor due to the concept which is established by keeping in mind a prototype developed by Theloy that quantifies the applied force as result of current supplied to joint motors. Meanwhile, the construction cost can be reduced because the device does not serve as a force measuring sensor. The device also does not give the accuracy in result of various reasons such as friction of joint, inertia in its linkages and winding resistance.

Another force sensing technique used in medical field is the current based method which provides high sensitivity and precision. This was authenticated by Tendono with 4-DOF pneumatic driven forceps. The system shows the remarkable performance in testifying the force applied to forceps by using neutral network estimate machine.

An often used method to quantify force requires the use of strain gauges. This is also known as resistive based sensing approach which is commonly used in the industry.

The piezoelectric sensing technique is another sensing technique which uses piezoelectric materials. The distortion of sensing structures are proportional to voltage signals produced by piezoelectric materials. This approach provides more sensitivity because even a small input of compression can cause a large output voltage. A larger output voltage means that the noise can be isolated and easily processed out. For developing tactile sensor the piezoelectric material used is polyvinylidene fluoride or PVDF.

A recently developed sensing technique used for measuring force is based on optical principle and brings more attention to sensing procedures. The important parts of this technique include a source of light, modulator and an optical detector. In the beginning of this process light is originated by using the source of light and then passes to the modulator. The detector then detects the modulated signal of light and then converts it into electrical signal

A sensor based on basic optics has gained fame. It includes a source, which produces light sending it to a modulator, which makes amplitude adjustments and finally read by a detector. It is then filtered, amplified and digitized. Examples include a sensor designed to determine tissue stiffness. The device includes LED, a photodiode and a sphere.

Steady air stream pushes sphere against the tissue, allows frictionless motion, thereby allowing swift study of large sections of a tissue. Sphere depresses the tissue and shifts a little. LED light is slightly affected, readjusted accordingly. Air flow adjustments can vary forced experienced by the tissue. Output is amplified, collected and analyzed. Optical fibers are often used for data transfer over long distances, allowing remote positioning of bulky elements.

Force sensing has proved valuable in soft tissue and minimally invasive operations by processing of tactile and force information. Medical robots allow a surgeon to make necessary decisions based on the aforesaid types of information during laparoscopic and open procedures. Da Vinci Surgical system presents 7 degrees of freedom ideal for small end effectors yet it doesn’t allow the surgeon to be in the same environment as the examined tissue.

While using the Da Vinci, tactile and force information is invisible to surgeons who resort to a three dimensional laparoscope to reverse engineer haptic feedback, improving quickly, to recompense for loss of touch sensing.

To name a few examples, MIS pincers with force sensors, exchange to create a visual image, and asymmetric analysis of tactile information on a few variables to determine useful forces. Sterile MIS sensors capable of delineating tactile information on all variables, and preserving a system while procedure carryout while avoiding miniaturization are commercially unavailable. Ongoing research still shows promise.

Apart from tactile feedback, certain mechanical properties of soft tissues allow determination of the tissue type and improve surgical accuracy. For instance, research shows that different types of cancerous prostatic and liver tissues have different stiffness, thereby allowing a higher accuracy in diagnoses in minimally invasive surgical treatments of prostatic hyperplasia and liver cancer.

Most soft tissues, being incredibly incompressible, anisotropic, viscoelastic, internally porous, and environmentally dependent, exhibit hysteresis loops and creep, reaching a steady state after many cycles. These properties are compounded when dead soft tissues degrade. Nonlinear stress strain function hyper elastic theory applies generally when ignoring deformation.

Linear viscoelasticity, derived from the superposition principle, sometimes explains tissue behavior. In other words, strain and stress are directly proportional. In mechanical models, such as Hooke’s law and Newtonian viscosity, spring and dashpot are the respective representatives. Other basic models include Voigt, Maxwell and Kelvin. More variables can be added to make complicated models that better describe the observable data, whereas all can be reduced to two formations.