TELEOPERATION OF SURGICAL ROBOT USING FORCE FEEDBACK

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Introduction Robotic Minimally invasive surgery (RMIS) can reduce recovery time of the patient [1]. However as the surgeon has to rely solely on live video feed to assess the force used, surgical errors are made and operation time is extended [2]. It has been shown that force feedback can improve performances in RMIS [3]. The present project aims at implementing force feedback on a telemanipulator controlling on a da Vinci surgical robot's end-effector. The end-effector lacks force sensors, implementing one is economically not feasible, since the tool needs to be discarded after a few uses [4]. The idea of force estimation based on current measurements is explored. Estimation poses a challenge, since the dynamics of the surgical tool are strongly nonlinear. Force feedback demands high speed communication.

Methods and Proposals The refresh rate of the communication between the main processing unit and the embedded system is increased by reducing the size of the exchanged data and changing the transport protocol used.
A Hammerstein-Wiener model for estimating the force is derived. The linear model required for Hammerstein-Wiener model is built through black-box estimation. The data used for estimation of the model is collected using the embedded system and a load cell.

Results The refresh rate of the communication reaches 638 Hz with a packet loss of 1.2%. The force estimation can track variation in forces applied by the end effector, however the feedback tend to emphasis small forces.

Discussion Refresh rate has been significantly increased compared to the original communication that could not exceed 100 Hz. However to meet the high demand of force feedback, the frequency should be further increased to 1 kHz, this could be achieved by optimizing the algorithms and implementing compression of exchanged data.
The estimated force is oscillatory in some situations. Promising results have been obtained in simulation by using a friction model to detect when external forces are applied.

References

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