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Zwei visuelle Steuerungskonzepte für dynamische Registrierung bei totaler Knie-Endoprothetik

Two visual servoing concepts for Dynamic Registration in Total Knee Arthroplasty

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Objectives

In robot-assisted orthopedic surgery the spatial relation (registration) of anatomical object and robot end-effector has to be known during the whole operation. In active as well as semi-active procedures this is realized by a rigid registration in the beginning of the operation. During the intervention the initial registration is maintained by an invasive clamping. Problems with the fixation occur due to unanticipated movements of the anatomical object which demand a new registration. Because of the invasive character lesions of soft and hard tissue cannot be excluded.
To this end a semi-active system will be developed which applies so-called dynamic registration. The robot is provided with a certain sensor - in this case vision - to react autonomously on motions of the anatomical object and to compensate for them. This new skill of the robot is first of all applied to the tibia cut in total knee arthroplasty, because of its 2D character.

Material and Methods

The experimental set-up consists of an industrial Stäubli RX130 and a vision sensor. For the latter two approaches are considered. Visual servoing algorithms for both cases are developed which allow tracking an object by the robot.

The first sensor is an intelligent digital INCA311 camera of Philips which is directly connected via a serial RS232 line to the Stäubli. The visual servoing is realized by template tracking with the help of a correlation search algorithm of the template in the captured images.
The second approach consists of a 6D measurements system which is used e.g. for robot calibration. The Krypton K600 DMM can measure with high accuracy in 3D the position of active markers (LEDs) with the help of three infrared cameras. In a real-time version the positions of markers can be sent with a frequency of 700Hz to a controller PC.

Results and Conclusions

For both vision sensors 2D tracking algorithms are developed, commanding the robot to follow the movement of the object. For the INCA311 the tracking error is less than 1mm. Performance tests are realized which show the feasibility of an operation procedure with a similar set-up.
The first results show that the internal Adept Controller of the Stäubli implicates a very high latency (delay) of about 80ms. In the case of the INCA camera the latency is even higher, due to the additional latency of the camera of about 100ms. Because of these results it is obvious that the experiment is important as a proof of concept for medical application. However for achieving a realistic set-up the Adept controller has to be bypassed or another robot has to be chosen.
On the other hand the Krypton system shows in the real-time mode an internal latency of 2.2-8.7ms by measuring one LED. The measurement frequency is 100 Hz and the kernel frequency of the controller PC varies between 1000Hz and 100Hz. For this approach also the latency of the robot will be the critical factor and has to be measured in the near future.


PHILIPS
Inca


KRYPTON