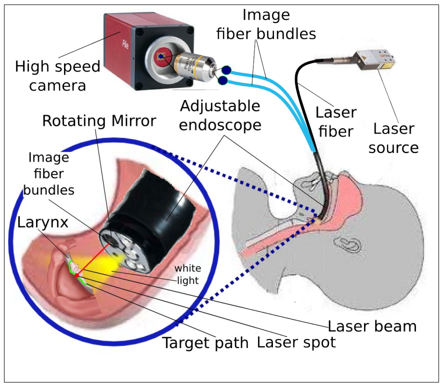
Preliminary variation on vision-guided laser phonomicrosurgery using multiview geometry

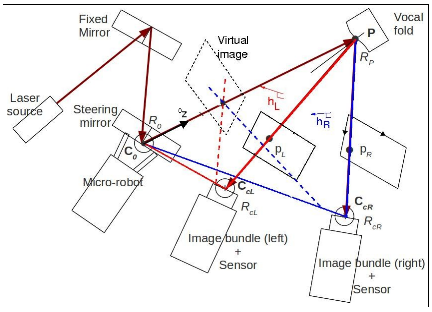
Sounkalo Dembélé, Brahim Tamadazte, Syed Zill-e Hussnain, Nicolas Andreff
Institut FEMTO-ST, Université de Franche-Comté/CNRS/ENSMM/UTBM, 24 rue Savary, 25000 Besançon, France

This work focuses on vision-guided laser surgery of the vocal folds. It is part of the FP7-ICT project "µRALP". A new surgical device is studied: it will be flexible and small enough to pass through the mouth and throat and come closer to the vocal folds. It will include a flexible laryngoscope, some image bundles to return images of the vocal folds, an optical fiber to provide the intervention laser beam, a rotating mirror to steer the laser beam and channels for tools. From an interface the surgeon will define the path of the laser for intervention (ablation as well as dissection) on the deseased tissues and then switch on the device.



The device will allow the achievement of accurate interventions. Indeed, the laser will be very close to the tissues (about 20 mm) and controlled using visual servoing approaches known to be stable, precise and robust. It will reduce post-operative pains for the patients by maintaining the neck in a comfortable position during interventions.

The study deals with the control of the rotating mirror that will steer the laser beam. Two control laws are proposed, both based on multiple view geometry.

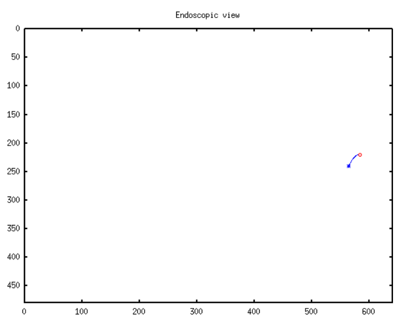


Firstly it is shown that the mirror can be represented by a virtual camera whose optical center corresponds to the center of rotation. Then, the position and velocity (ω) of the laser spot in the virtual image is directly linked with the mirror position and velocity, respectively.

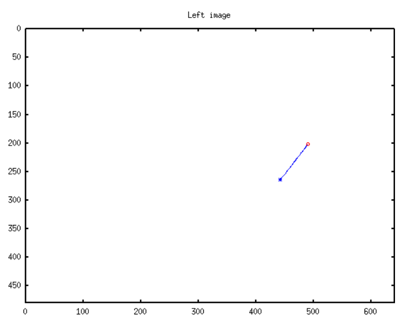
Secondly, the two-view system consisting of the mirror and one image bundle is considered. It is characterized by the fundamental matrix **F**. The derivation of the epipolar constraint of the system and the interpretation of the geometric relations of the system leads to the control law ω(**F**).

Finally, the three-view system consisting of the mirror and two image bundles is considered. It characterized by the fundamental matrices $\mathbf{F}_L$ (mirror-first image bundle) and $\mathbf{F}_R$ (mirror-second image bundle). The derivation and interpretation of the geometric relations leads to the control law $\omega(\mathbf{F}_L, \mathbf{F}_R)$.

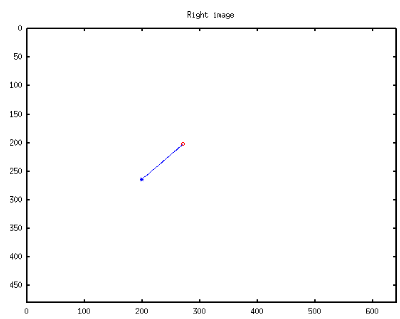
The Control laws are tested in simulation. The solution with three views gives a better result: the path is linear indicating a perfect decoupling between the degrees of freedom of the mirror.



Trajectory in the image (2-view)



Trajectory in the first image (3-view)



Tractory in the second image (3-view)