Context
For ground-based telescopes, the inhomogeneities in the air refractive index, due to turbulence in the atmosphere, affect negatively the quality of the image onto the detector. Adaptive optics (AO) is a mean to compensate the degradation by correcting the optical path variations (wavefront). Such a system will be used on the NIRPS (Near Infra Red Planet Searcher) instrument, an international collaboration between the iREX team at the Université de Montréal and the Observatoire Astronomique de l’Université de Genève. The NIRPS (Near Infra Red Planet Searcher) instrument is an infra-red spectrograph to detect exoplanets similar to Earth, which will be installed on the ESO 3.6-m telescope in La Silla, Chile.

Motivation
It has been noted that spurious vibrations, which will affect negatively the performance of the instrument, are present on the telescope, coming from different sources such as other components of the system (for instance coolers, motors or fans) or wind-shaking of the structure. Therefore a new controller is needed, satisfying the following conditions:

• Have similar (or better) performances than the current controller, when no vibration is present.
• Damp one or more constant sinusoidal perturbations at unknown and slowly variable frequency, which needs to be identified.
• Keep computational load/complexity as low as possible while satisfying the two first criterion.

Controller
• First, computation of a set of N stable controllers for perturbation models $M(z, \omega_p)$ at different frequencies $f_p = \omega_p / 2\pi$, based on the old controller open loop transfer function.
• Then, design of a linear fixed-order $H_{\infty}$ gain-scheduled controller based on the internal model principle using the N open loop transfer function of the stable controllers as desired open-loop transfer functions for each perturbation model.
• Perturbation frequencies are used as scheduling parameters.
• Minimization of the weighted-infinity norm of the sensitivity function with a constraint on modulus margin.
• The controller is implemented for a perturbation model with up to three distinct frequencies.

Identification
An adaptation algorithm with constant trace is used to:

• Estimate the perturbation frequencies.
• Update the controller in real time according to the estimated frequencies.

Results
Procedure: In phase 1, no disturbance is present. In phase 2 the vibration is applied and in phase 3 the controller is tuned to the identified frequency.

• Frequency estimation accuracy is within 0.2 [Hz] for one and two frequencies and 0.26 [Hz] for three frequencies.
• Time varying frequencies can be tracked accurately.
• Improvement in RMS values between 93.4% and 97.8 % compared to old controller.
• Improvement in the attenuation at the perturbation frequency > 28 [dB] for most of the frequencies.

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