AN UPGRADE OF THE HARPS-N SPECTROGRAPH AUTOGUIDER AT TNG

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ABSTRACT

HARPS-N is a high-precision radial-velocity spectrograph installed on the INAF – Telescopio Nazionale Galileo in the island of La Palma, Canary Islands. The HARPS-N project is a collaboration among several institutes lead by the Astronomical Observatory of the University of Geneva. The HARPS-N control software is composed by the Sequencer, which coordinates the scientific observations and by a series of modules implemented in LabVIEW for the control of the instrument front end, calibration unit and autoguider. The autoguider is the subsystem in charge of maintaining the target centered on the spectrograph fiber. It acquires target images at high frequency with a technical CCD and with the help of dedicated algorithms keeps the target centered on the fiber through a piezo tip-tilt stage. Exploiting the expertise acquired with the autoguiding system of the ESPRESSO spectrograph installed at the ESO VLT, a collaboration has been setup between the HARPS-N Consortium and the INAF - Astronomical Observatory of Trieste for the design and implementation of a new autoguider for HARPS-N.

HARPS-N DESCRIPTION

HARPS-N (High Accuracy Radial velocity Planet Searcher - North) is an echelle spectrograph installed on the INAF - TNG in the island of La Palma, Canary Islands [1]. It covers the wavelength range between 383 to 693 nm, with a spectral resolution R=115000. The instrument allows the measurement of radial velocities with the highest accuracy currently available in the north hemisphere. The main scientific rationale of HARPS-N is the characterization and discovery of terrestrial planets by combining transits and Doppler measurements.

HARPS-N AUTOGUIDER

HARPS-N current autoguiding system (AG) has been developed in 2012 using the LabVIEW programming language. This choice has been driven by the requirements of controlling several devices in parallel:

- Technical CCD (camera).
- Piezo controller for the tip-tilt mirror.
- 3-axis motion controller for the neutral density filters.

The role of the autoguider is to correctly center the star on the fiber during the acquisition phase and to keep the star on the fiber, during the observation phase, by continuously moving a piezo tip-tilt mirror using small computed corrections in addition to the telescope tracking system.

HARPS-N AUTOGUIDER UPGRADE

After few years of operations, the maintenance of the LabVIEW-based autoguider software proved to be difficult, due to strong dependencies both inside the LabVIEW VIs (Virtual Instruments) and between the AG and the Local Control Unit - LCU (Software which control the calibration unit of HARPS-N). The system startup was also very complicated due to several initialization phases, which slowed down the system considerably. For these reasons it was decided to redesign the entire software from scratch, trying to simplify it based on the experience gathered with the ESPRESSO instrument [2].

AUTOGUIDER DESIGN AND IMPLEMENTATION

Hardware architecture

The HARPS-N AG hardware is composed by the following parts:

- Shuttle PC, where the AG-Core module is installed. The OS is Linux Debian 9.
- FLI (Finger Likes Instrumentation) ProLine 4210 camera.
- Tip-tilt piezo controlled by a PI (Physik Instrumente) E-517 controller.

Software architecture

The new AG software consists of two modules (see Figure 1): the AG-Core and a web-based GUI. The two modules communicate using a *REST* implementation.
The AG-Core software is implemented in *C++11* and is composed by several threads. Besides the main thread, one thread performs the image acquisition and other two threads perform the required computations via dedicated algorithms.
The communication with the FLI camera is realized through the *FLI Software Development Library* (version 1.40).
The communication with the tip-tilt piezo is realized through the *PI GCS2 library* (version 2.4.0).
The configuration file is written in *JSON* format and all the relevan information is stored in a *Redis* database.
The GUI is based on *Vue.js* [3], constantly polls the AG-Core through HTTP GET requests and is able to POST new parameters to the guiding loop.

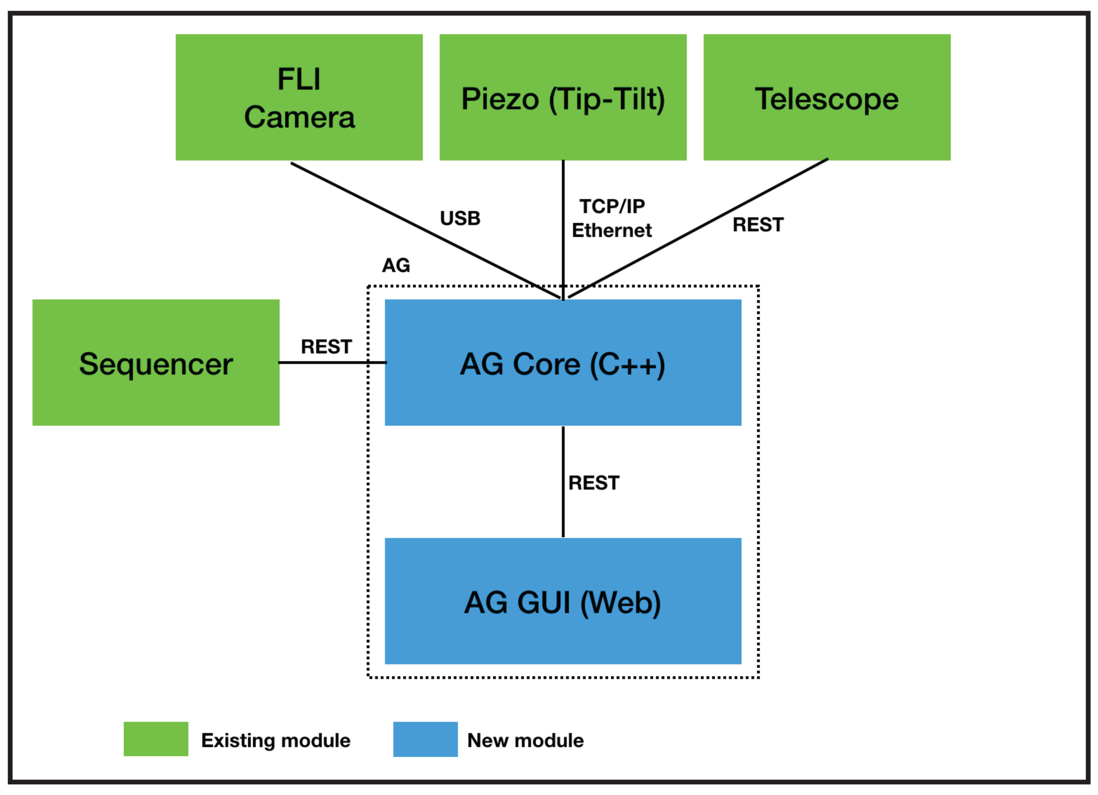

Figure 1: HARPS-N autoguider control architecture.

FIRST COMMISSIONING RESULTS

In September 2019 the new AG system has been tested on the HARPS-N instrument at the INAF – TNG Observatory. Figure 2 shows the INAF - TNG telescope operator workplace with new HARPS-N AG GUI in operation.
Figure 3 shows the Field stabilization tab of AG GUI during one of the first observations. The left image on Figure 3 shows the "*live image*" together with the current centroid determination (red cross), mask circle used to compute the background (green circle) and fiber center position (blue cross) . The right image shows the "*integrated image*" which is used to continuously adjust/calculate the central fiber position.
As can be seen the system was able to deliver *very good results* on a Mv ~ 8 mag star already after the first trial: with an exposure time of 0.2 s (visible on top left) the mean correction (in arcsec units, visible on the two graphs, bottom) is less than 0.001 arcsec both in X and Y direction with an r.m.s. of the order of 0.2 arcsec, well within the scientific requirements.

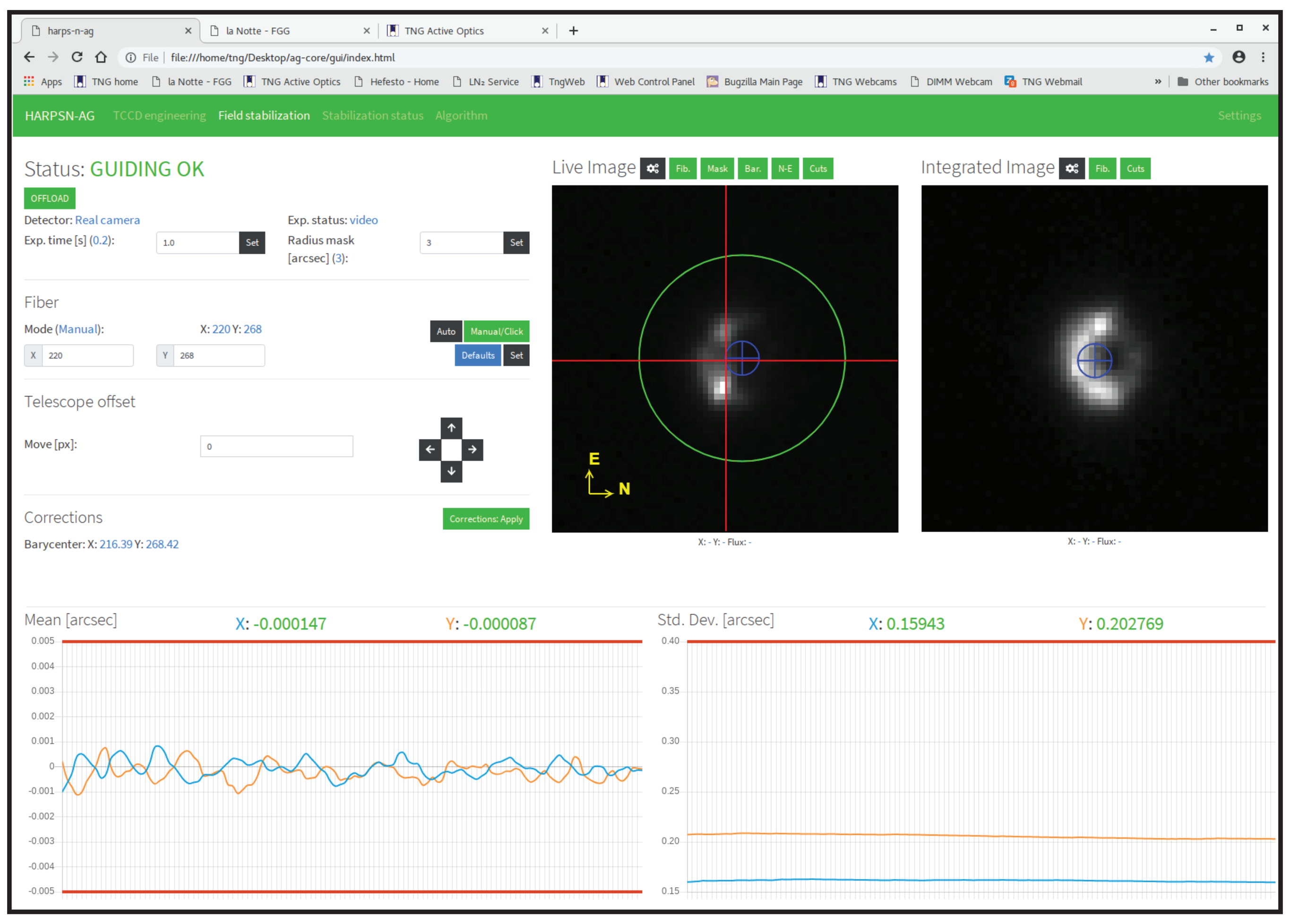

Figure 3: HARPS-N AG GUI (Field stabilization tab).

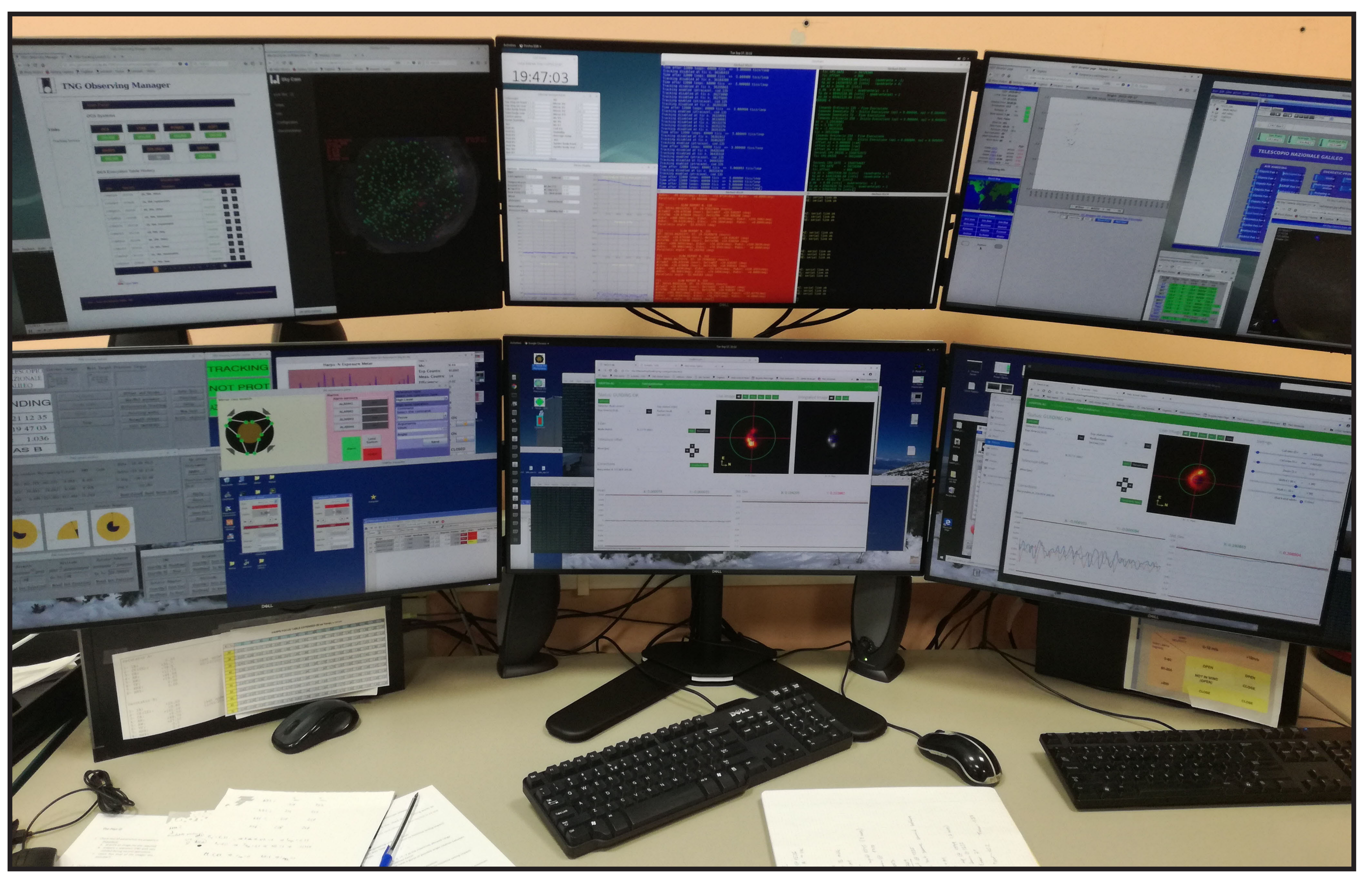

Figure 2: INAF – TNG telescope operator workplace.

REFERENCES

[1] http://www.tng.iac.es/instruments/harps
[2] Landoni M., Cirami R., et al., "ESPRESSO front end guiding algorithms: from design phase to implementation and validation toward the commissioning", Proc. SPIE 2016 (Edinburgh), Software and Infrastructure for Astronomy IV, Vol. 9913, 99133Q.
[3] https://vuejs.org

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