Thought about artificial intelligence application for astronomical observation

Ge Liang, Zhao Yong

National Astronomical Observatories, Chinese Academy of Sciences(NAOC)

geliang@nao.cas.cn zhaoyong@nao.cas.cn

Abstract: **This paper proposes to introduce the artificial intelligence (AI) to astronomical observations. On the basis of the centralized control of multiple telescopes, combining the information of observational requests, observational plans, logs of instruments, environmental parameters, we will carry out the research on the intelligent customization and the real-time adjustment of the observational strategy. Moreover, based on our experience of years of operation and maintenance of telescopes and the huge amount of historical data, we will collate and establish a fault tree of astronomical observational system, and break through the key technique of intelligent fault diagnosis through machine learning.**

Introduction

Small and medium aperture ground-based optical telescopes, particularly 1-meter class telescopes, still play an important role in many fields of astronomical observations, especially in the study of time domain astronomy. The observations of time-domain astronomy raises new requests to the geographical distribution, sky coverage, response speed, and duration of observational time of instruments, as well as the ability of coordination among different instruments.

We want to apply AI to astronomy, and the benefits are as follows:

•Improving observation efficiency: observation strategy decision, observation time allocation, use more spare time.

•Reducing failure rate: avoid repetitive work, auxiliary decision-making function, avoid the impact of human operation, intelligent fault diagnosis.

The centralized control system of XO

The Xinglong Observatory (XO) of the National Astronomical Observatories, Chinese Academy of Sciences (NAOC) (IAU code: 327, coordinates: 40° 23′39″ N, 117° 34′30″ E) was founded in 1968. As the largest optical astronomical observatory site in the continent of Asia, it has 9 telescopes with effective aperture larger than 50 cm. (see Fig 1).

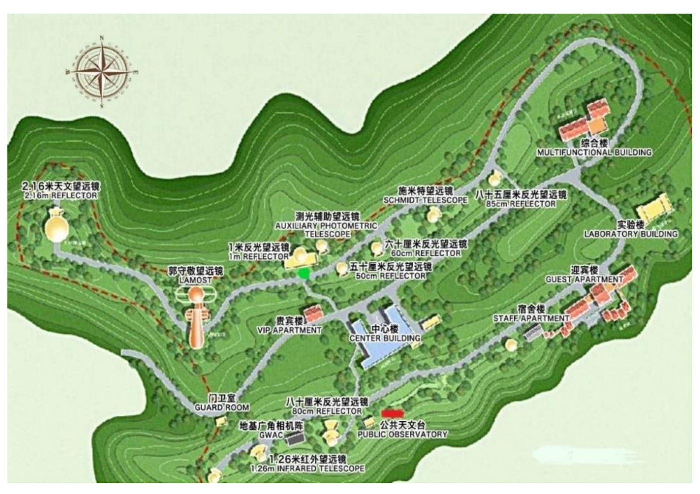

Fig. 1 The floor plan of Xinglong Observatory

The XO has a large number of telescopes with varying apertures and ages, which are located in different locations of the observatory. The observation of this decentralized model has the following problems: the hardware, control software, observation processes and data formats of the telescope systems are different and difficult to manage and dispatch in a unified manner.

Therefore, from 2013 to 2018, we have finished the centralized control of XO, which has the following advantages:

•Improving the observations quality of telescope.

•Improving the observation efficiency of the telescope.

•Conducive to the formation of a unified telescope observation norms.

•Improving the automation of telescopes.

•Provides the foundation for intelligent control telescopes

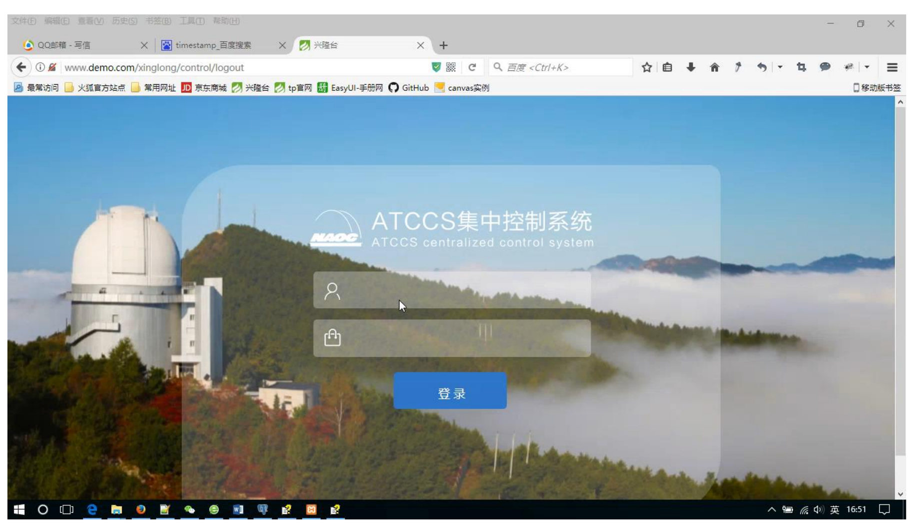

Fig. 2 The login screen of the centralized control system of XO

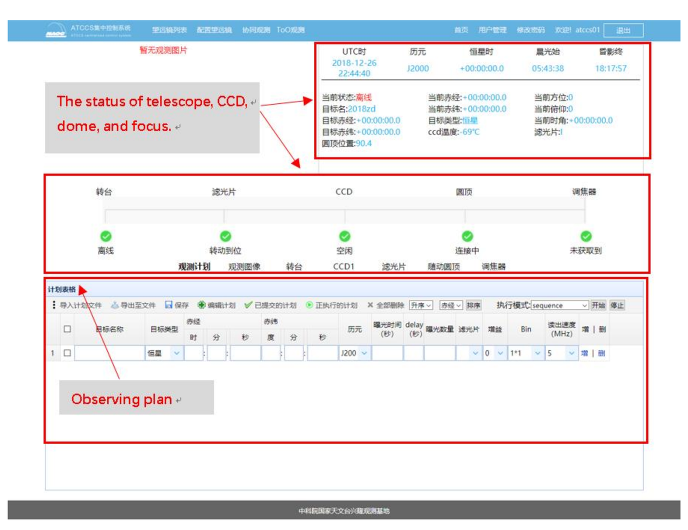

Fig. 3 GUI of the observation

In the interface of centralized control system of XO (see Fig 3), we showed the real-time status of telescope, CCD, dome, and focus.

For normal observation, we could used the centralized control system for sequential observation.

For Target of Opportunity (ToO), like Gamma Ray Burst (GRB) and Supernova, we have setup a priority observation. When ToO arrives, we'll make observations immediately.

The observational strategy

In general observations, there is a observing library, what instrument is used and exposure time, whether the observation is successful (Yes/No), as a data set to learn, and later to determine whether it can be observed. After two years of slow learning, the automatic judgment can be observed or not, parameter setting, priority and other intelligent observation.

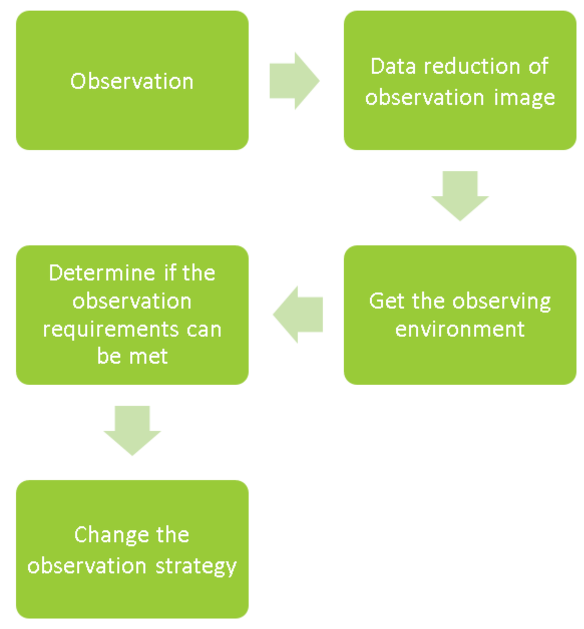

Fig. 4 The steps of adjust strategy.

When observing, the real-time adjustment of observation strategy requires parameters: The signal-to-noise ratio, real-time change of seeing , atmospheric extinction value, sky background brightness, target and moon angle, atmospheric aerosol content, and the choice of grating or filter, etc. Real-time data reduction of observation image, extract star information, determine whether to adjust the observation strategy according to environmental changes, as shown in Fig 4.

The fault tree of astronomical observational system

Based on our experience of years of operation and maintenance of telescopes and the huge amount of historical data, we have build a fault tree of astronomical observational system, which have five steps, as shown in Fig 5.

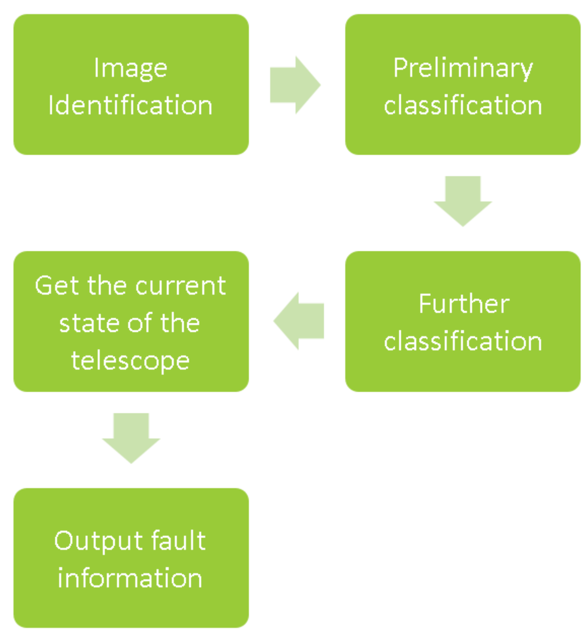

Fig. 5 The steps of fault tree.

The first step is to classify the observed images through convolutional neural networks to determine the approximate types of faults. Then the classification results are sent to the next program, which obtains the telescope's operating status and data by docking with centralized control software, and then combines with the previous classification results to further classify the more detailed results.

Conclusion

Fig. 6 Scene of the centralized control hall of XO.

After the completion of the centralized control system of XO, all telescopes can use a unified interface and protocol to observation. In addition, observers can observation in the centralized control hall, providing a technical basis for the transformation of the AI telescope.

We will carry out the research on the intelligent customization and the real-time adjustment of the observational strategy. Moreover, we will collate and establish a fault tree of astronomical observational system, and break through the key technique of intelligent fault diagnosis through machine learning.