SPIKE scheduler is not restricted to HST scheduling problems and has successfully been applied on a trial basis to schedule observations for the International Ultraviolet Explorer (IUE), the Extreme Ultraviolet Explorer (EUVE) and ESO's 3.6-m telescope.

Full-text retrieval. Retrieval of astronomical bibliographic full-text information is another area, for which the application of AI-techniques has been proposed originally for the machine-readable version of Astronomy & Astrophysics Abstracts (Adorf and Busch, 1988) and is now being realized within the American Astrophysical Data System (ADS), a distributed database system which incorporates all major astronomical space-borne databases.

Symbolic computation. Symbolic computations are required e.g. in the process of solving integrals or differential equations. For quite some time, there exist computer programmes which can assist in carrying out such tasks. In physics, these programmes are mainly being used for elementary particle or general relativity computations. One of these programmes, available at ESO, is Mathematica, a comprehensive system for doing mathematics. It allows one to easily solve algebraic equations, to multiply matrices, to integrate complex formulae, etc., all on the symbolic level. Results can be cast into FORTRAN-, C- or TEX-form, or can be graphically represented. Arbitrary precision arithmetic can be used to solve problems, which can only be computed numerically. A convenient interface allows easy access to the functionality provided by this modern research tool. Mathematica has successfully been applied at ESO to optical design problems.

Classification. This seems to be a natural area for the application of artificial intelligence techniques to astronomy. Already in 1986 a rule-based classifier for the morphological classification of galaxies was devised by the French computer scientist Monique Thonnat (see Heck and Murtagh, 1989). Other classifiers have been designed for the classification of IUE low-dispersion spectra and of low-resolution spectra from the Infrared Astronomical Satellite (IRAS). Trainable neural networks offer some potential for difficult classification tasks such as the detection and discrimination of cosmic ray hits on images from solid-state detectors in space.

The Future

Artificial intelligence in astronomy has neither as bright a future as some see it, nor as dark a future as some others do. It is easy to imagine a number of areas, still outside the core of astronomy, where AI-techniques may play a role in the future.

The increased complexity of computer systems will require better human-computer interfaces. The operation of ground-based observatories also seems to increase in complexity, and may reach a stage beyond the level which can quickly and reliably be handled by humans. Absentee and split-schedule observing modes will become more common. Coordinated multi-frequency observations, which require the synchronization of several ground-based and satellite observatories, could be facilitated by the help of sophisticated schedulers. Planned planetary missions, if ever financed, will require autonomous observing capabilities. Retrieval by content of data from large image databases, adaptive control of "flexible" telescope optics or the optimization of arrays of telescopes may be possible using neural networks (see the discussion after Merkle, 1988, and Angel et al., 1990). There are already approved plans to provide assistance in the reduction and analysis of astronomical data by a computerized expert system (Millerj, 1990). All these areas may (and in the long run will) benefit in one way or other from methods and techniques developed in AI-research labs.

Conclusion

By considering a few examples we have seen that artificial intelligence techniques have already made an inroad into astronomy. The achievements described above have been established by few, dedicated people without monetary reasons as driving forces (as opposed to other areas such as geological oil exploration). It is fairly safe to expect more AI in astronomy in the future, related, of course, to the interest by the astronomical community and the amount of resources devoted to AI-research and astronomical application development.

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Editorial Note

The present *Messenger* issue exceptionally contains 84 pages, due to a late, unexpected influx of articles, reflecting an ever-increasing level of astronomical activity in and around ESO. It is, however, our intention to revert to the normal size (60–68 pages). This may mean that we will in the future be unable to accept contributions which are submitted after the stipulated deadlines, i.e. January 20, April 20, July 20 and October 20, for the March, June, September and December issues, respectively.