An Agent-Based Interface to Terrestrial Ecological Forecasting

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The latest generation of NASA Earth Observing System (EOS) satellites has brought a new dimension to continuous monitoring of the living part of the Earth System, the biosphere. EOS data can now provide weekly global measures of vegetation productivity and ocean chlorophyll, and many related biophysical factors such as land cover changes or snowmelt rates. However, the highest economic value would come from forecasting impending conditions of the biosphere, to allow decision makers to mitigate dangers or exploit positive trends. NASA's strategic plan for the Earth Science Enterprise identifies ecological forecasting as a focus for research. Ecological forecasting predicts the effects of changes in the physical, chemical and biological environment on ecosystem activity. Possible applications of such a system include predicting shortfalls or bumper crops of agricultural production, populations of threatened or invasive species or wildfire danger in time to allow improved preparation and logistical efficiency.

Petabytes of remote sensing data are now available to help measure, understand and forecast changes in the Earth system, but using these data effectively can be surprisingly hard. The volume and variety of data files and formats are daunting. Simple data management activities, such as locating and transferring files, changing file formats, gridding point data, and scaling and reprojecting gridded data, can consume far more personnel time and resources than the actual data analysis. Some scientists commit to a particular data source or resolution just because using anything different would be more effort that it's worth.

Better tools can help, but most of the tools developed to date are little more than shell scripts; they lack the flexibility to meet the diverse needs of users and are difficult to extend to handle changes in available data sources.

We are developing a more adaptable solution, a ***soft***ware ro***bot***, or *softbot* (also known as a software agent), a sophisticated computer program to which a person can delegate tasks. Our softbot, called IMAGEbot, is based on automated constraint-based planning and a flexible component-based architecture. Unlike script-based approaches, where the instruction sequences for managing and processing data are hand-coded, in our softbot-based approach, the instruction sequences are automatically generated based on user requests and available data sources. New data sources, models or data-processing programs can be added in a plug-and-play fashion, and the planner can adapt to errors or data dropouts by trying alternative ways of achieving the same goal, such as using other, possibly lesser quality, data sources.

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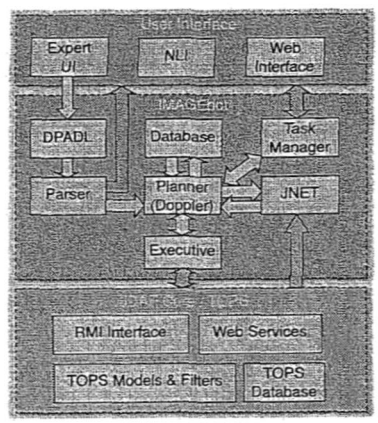

Fig. 1. The IMAGEbot agent architecture

We have demonstrated this technology in the Terrestrial Observation and Prediction System (TOPS), an ecological forecasting system that assimilates data from Earth-orbiting satellites and ground weather stations to model and forecast conditions on the surface, such as soil moisture, vegetation growth and plant stress. The planner identifies the appropriate input files and sequences of operations needed to satisfy a data request, executes those operations on a remote TOPS server, and displays the results, quickly and reliably.