Planning Systems in Hubble Space Telescope

Doing planning for HST is a complex problem for many reasons. In a year HST can analyze thousands of targets. There are a large number of interacting constraints with timescales covering several orders of magnitude (minutes to years). The Schedule is modified constantly as observations are made.

HST implements a two level hierarchical approach for its scheduling. Scheduling has been divided in two: Long-term scheduling, which allocates observations over a 1-2 year interval, and short-term scheduling, which covers a one-week period and creates a detailed timeline of activities.

Short-term scheduling program is called Science Planning and Scheduling System (SPSS). Long-term scheduling programm is called Spike. On this text we are going to focus on Spike.

Spike combines different techniques such as Constraint Satisfaction, Heuristics and techniques that are similar to Simulated Annealing.

Constraint Satisfaction is used to schedule observations based on several parameters. Those parameters can be: exposure, number of photographs, position of the HST (if the telescope pass through a high radiation zone), position of the target (if the target is hidden by earth or another object).

Many Hillclimbing Repair Methods and Heuristics are used in order to solve conflicts between observations. One of the heuristics used is called Min-conflicts, which moves activities to times when the number of conflicts is minimized.

Spike has been implemented in other NASA telescopes, this was possible because it was developed as a framework instead just for HST. It was developed using Lisp and Texas Instruments electronics.

When it launched, HST showed many issues with its lenses. This problem affected observations significally and was agravated by other software and hardware malfunctions. One of the things that engineers learned about this mission was that change was the norm and their main recommendation when developing planning/scheduling systems was that, at least for systems similar to HST, **planning must be built in the expectation of change from the outset.**

References:

- **Spike: AI scheduling for Hubble Space Telescope after 18 months of orbital operations**
https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19910013462.pdf

- **Long Range Science Scheduling For The Hubble Space Telescope**
https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19910013462.pdf

Planning In The Human Brain, Alpha Go Unique Style and The China Brain Project

The human brain has an area within the frontal cortex called the lateral frontal pole. It is responsible for the planning and desition making processes. Being able to plan into the future is considered a key feature of human cognition. A team of researchers from Oxford University found that there are significant differences between the lateral frontal pole in humans and other areas in monkey frontal cortex. We could say that a complex task like strategic planning is the result of biological evolution of specific parts of the brain, and this evolution may be triggered by different types of interaction between primitive humans and the environment, which is in student's opinion a requirement for the development of intelligence.

As well as there are differences between humans and monkeys, it might be necessary to think of the process of creating AI not as a copy/paste of human cognition processes, but as a process of creating systems that can develop its own mechanisms of thinking, then things like true destion making and strategic planning could emerge as a necessity based on the information the AI receives as input and the interaction it makes with other systems, living organisms or the real world. This could sound like science fiction for some readers but we already have AI agents that had developed it's own style on performing tasks that were thought only humans could do.

One of this examples is Alpha Go, which developed it's unique style of playing the ancient game of Go. It's being said by Go master players all over the world that Alpha Go's style is "not human", so it's clear that it is not only appling moves learned from analazing data from human vs human matches, but it has developed the ability to create its own strategies. To archieve this Alpha Go developers incorporeted very interesting search methods such as Montecarlo Tree Search, and combined these techniques with Multi layer Neural networks. Although individually these methods are not new and are currently used in other fields of AI such as Computer Vision, the way they interact inside Alpha Go is trully remarkable.

The interest of understanding the brain and the implementation of this knowledge in AI systems is now growing as countries like China are investing significant resources in the research and applications of brain-inspired computational models and devices. **The Chinese Brain Project** is formulated as a 15 year plan to increase interest of chinese researchers in Neuroscience and its application in other fields like medicine and computer science, and it is also an effort to use discoveries on this areas to address societal problems.

References:

- Comparison of Human Ventral Frontal Cortex Areas for Cognitive Control and Language with Areas in Monkey Frontal Cortex
http://www.cell.com/neuron/fulltext/S0896-6273(13)01080-5

- Mastering the game of Go with deep neural networks and tree search
https://storage.googleapis.com/deepmind-media/alphago/AlphaGoNaturePaper.pdf

- China Brain Project: Basic Neuroscience, Brain Diseases, and Brain-Inspired Computing
http://www.cell.com/neuron/fulltext/S0896-6273(16)30800-5