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AUTHOR(S)   Stirling A. Colgate, T-6

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Los Alamos Los Alamos National Laboratory
Los Alamos, New Mexico 87545

AUTOMATED SUPERNOVA SEARCH

Stirling A. Colgate

New Mexico Institute of Mining and Technology
Socorro, New Mexico 87801

and

Los Alamos National Laboratory, University of California
Los Alamos, New Mexico 87545

INTRODUCTION

A program for the development of an automated supernova search based upon complete remote computer control of a telescope and vidicon digital imaging system has been under development at New Mexico Institute of Mining and Technology, Socorro, New Mexico, since 1968. This very long time has seen the multiple development of many systems as well as some failures. The primary problem has been the complexity of the software system.¹ Although, in the early days several different digital image tubes were developed, among which were Orthicons and Iuocons, before the present system of an intensified Vidicon silicon target tube was put in place.² The software problem is a more subtle problem than the single components of hardware.³ However, before going into software in depth let us consider the scientific objectives.

One would like to detect supernovae at an early stage of their light curve in sufficient numbers to establish some of the following criteria:

1. One would like to understand if the early light curve is derived from a shock wave in an extended envelope or by an internal energy source; for example, the radioactive decay of Ni^{56} etc.

2. One would like to understand if the luminosity at peak is consistent with an internal energy source that may be radioactivity or by a hydrodynamic shock wave or early pulsar emission, and compare this to theories of the origin of supernovae, whether thermonuclear energy release or dynamic collapse to a neutron star state.
3. One would like to obtain sufficient statistics of the peak and width of all types of supernovae to understand the consistency of the initial state and the consistency of the surrounding environment of the supernova. For instance, type I supernova occurring in E-galaxies with negligible gas and dust may exhibit sufficiently repetitive light curves to serve as a secondary standard in the measurement of the size and curvature, H_0 , q_0 of the universe.^{4,5}
4. One would like to obtain sufficient statistics of supernovae concerning their location within galaxies as well as the galaxy type, and ultimately extend that study to large enough Z to determine a possible evolutionary factor in the occurrence of supernova as a measure of stellar evolution in galaxies as a function of time.

These questions are best served by a system that images galaxies sequentially and attempts to find a difference in the galaxy image past and in the present, indicative of a point source of light increasing in luminosity with a time constant of days to weeks. This requires (1) storing a previous image and comparing it to a present one, (2) maintaining a catalogue of galaxies as well as part images, (3) a catalogue system that keeps track of false alarms and contains sufficient logic to deal with these in a hierarchy of exclusion tests, and (4) a system which can continue for long periods of time unattended because of the intense boredom of monitoring a system that is performing a highly repetitive, although complex, function. It was therefore the objective from the beginning to develop a stand-alone system of a telescope in a dark, good seeing site controlled through a microwave link from a computer on a campus where students could take turns in ultimately and hopefully the relatively routine function of computer operation.

This system almost reached operational status but was terminated in 1974 for several reasons.

1. No further external funding was available.
2. The computer, IBM 360, Model 44, was completing its natural life after 10 years at the institution and the maintenance requirements were becoming so excessive that negligible night time or off hours use was feasible.
3. Probably most important, the software structure had become so complicated that debugging and modifying it became impractical because of the immense difficulty of tracing an unoperative interaction throughout the whole system, roughly 100,000 FORTRAN statements in size.

The question naturally arose whether the entire system should be dismantled. On the other hand, the hardware on the mountain, although constructed to a significant extent of surplus components, was still significantly beyond the state of the art. This included: telescope mount driven by digital stepping motors in a feedback mode that could slew the telescope a radian in several seconds of time with an accuracy of better than 10 s of arc. It used a special light-weight design with a self-supported central mirror and allowed the change of focal ratio from F-30 to F-12 to take place in less than 5 s. It contained a fully automated cross dispersed eschell spectrograph and an intensified Vidicon digital image tube system that operated without attention remotely for many months at a time. In addition, a microwave link had been developed with a dropout rate of less than 1 in 10^6 bits which was adequate for the purpose in question. Finally, there was the relatively complicated decoding and query logic in place for all the many functions needed to operate such a system provided the appropriate 16-bit words were transmitted to the mountain. This seemed such a significant development in itself that the consideration of a computer with its software to direct this system seemed to be a feasible addition that could take place at a relatively modest level of investment over an extended period of time.

A possibility to do this arose with the funding to purchase a Prime 300 minicomputer for the joint use with the atmospheric sciences with the specific capabilities of multiuser and virtual memory operating system. The reason for this is the recognition that the software effort will be many times larger than the hardware effort. It therefore stands to reason that if you have one task 10 times greater than the others it is wise to have more than one person work on the problem simultaneously. This is why the operating system must be a multiuser virtual memory time shared system.⁶ Multiuser includes not only multiprogram access, but also multitasking where a separate task (like a user) is assigned to each of several telescope functions; e.g., telescope slewing, the digital cameras (CCD or SIT), star field pattern recognition, spectra, guiding, frame "taking", reduction and calibration, catalogue access and maintenance of stars, galaxies, quasars, and nebulae. A multitasking operating system allows all of these functions to be operating concurrently provided a real time interrupt of the operating system can take place. Most multiuser operating systems assign a sequential time slice to each user. A telescope must be able to command attention with a priority above other tasks.

In addition there must be:

1. User observation program testing, development and scheduling.
2. User data formatting and presentation.

3. User intervention.
4. Interlocks, telescope safety, and fault diagnosis.

A multiuser environment allows any task to talk to another task by passing parameters much like the function "mail" where any user passes messages to other users.

Many may ask why not use a separate microcomputer for each task? One then has the problem of networking all these computers - which can be done but it is presently much more difficult - again because the software effort is much greater than the hardware effort. It is much more efficient to time share one CPU that "knows" where everything (everyone) is located and where the operating system is a development used for thousands of installations.

We have been modifying a Prime 300 (a 16-bit minicomputer with 256K core and 80 Mbyte disc) multiuser time sharing system to handle priority interrupts so that we can perform multi-tasking in a real time environment.

Currently the Prime 300 operating system has been modified to perform priority interrupt real time transfer of data to and from the mountain via microwave link. All programs are imbedded in a multi-user environment. In addition, message passing between tasks has been implemented so that parameters are easily available to all programs. Many other system changes have been implemented to accomplish this and roughly 3/4 of the operating routines have been rewritten and are operational.

A telephone modem interface with call-back using the state Watts telephone system allows users to log in with a remote terminal.

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