# An Automatic Supernova Patrol Acquisition System

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### Introduction

The search for supernovae is a very demanding business. It entails the acquisition of many thousands of images. Every image must be examined in detail for signs of an exploding star. The search for supernovae places a large burden on the individual, who must remain awake and alert throughout the whole night when executing patrol runs. In the past amateur supernova hunters have had to direct the telescope to the desired galaxy, acquire an image of the galaxy, compare this image with a reference image and if no supernova is present move onto the next galaxy. It is clear that this process is a very time consuming task and under some circumstances, mistakes can be made. With this in mind, this article describes a system developed by the author for the automatic acquisition of supernova patrols. The system enables a supernova hunter to concentrate on supernova detection, while a computer handles all other tasks.

### The system

Figure 1 shows a simplified control flow diagram of the system. There are three major parts to the system:

1 Galaxy acquisition,
2 Image comparison and
3 Supernova detection.

each of these shall now be described in more detail.

The acquisition part of the system first reads a text file that contains the galaxies names and coordinates for a patrol run, see the example below. The galaxy list is generated using The Sky software. The user highlights a region of the sky and saves all the galaxies of interest in that region to a text file. A routine is provided to read this file and sort it according to the galaxies RA. The galaxies with the most Western RAs will be processed first. The sorted galaxy data are then saved to another text file, which is read by the system.

```
109
1  NGC7803          00 01 16  13 06 17
2  UGC12914         00 01 34  23 28 38
3  UGC12915         00 01 39  23 29 14
4  NGC7814          00 03 11  16 08 18
5  UGC14            00 03 32  23 11 34
6  NGC7816          00 03 45  07 28 21
7  NGC7817          00 03 55  20 44 33
Etc.
```

Figure 2 - An example of a patrol input file.

After reading the galaxy data file, the system will move the telescope, 10" LX200, to the first galaxy coordinates. A small settling time is applied after slewing. At the end of the settling period, the system will start an image integration. The camera used is a Starlight Xpress parallel port SX camera. At the end of the image integration, the image is downloaded from the camera and saved to disk. The system saves a header with the image data. This header contains the object name, coordinates and time of acquisition. The telescope is then moved to the next galaxy and the sequence repeats.

When the next integration is underway, the system will display the image just acquired. There is an option to automatically subtract a dark frame from the observation image before it is displayed. A zoom window is also generated that shows the central region of the observation image magnified by a factor of four.

A reference image is then read from the hard disk and displayed in a separate window. The observation image and the reference image are aligned and in another window the images are sequentially displayed, i.e., they are blinked. The images displayed can be brightened by pressing the left arrow key. This allows the user to check for dim objects away from the nucleus of the galaxy. The images can also be made dimmer so that objects near the core of the galaxy can be examined. The blinking process proceeds concurrently with the present galaxy acquisition. At the end of the current integration, the new observation image is downloaded and saved and the process starts all over again.

If, after a number of hours of acquiring images, the galaxies are not centered on the observation image the system can be paused, the telescope re-syncronised, then the acquisition can continue with the next galaxy in sequence. If an object needs detailed investigation, the system can be stopped and the object can then be examined more thoroughly. After which the system can resume the acquisition process.

Figure 3 shows an example of the system. The galaxy displayed near the centre of the observation window is NGC4266. The example shows an asteroid, magnitude 15.3, close to the galaxy. This asteroid can easily be seen in the observation image and the zoom window. The reference image has been shifted so that it is aligned with the observation image. The asteroid was readily spotted in the blink window. Although this example shows an asteroid and not a supernova, it is clear that if a supernova were present in the galaxy then using this system would help detect it.

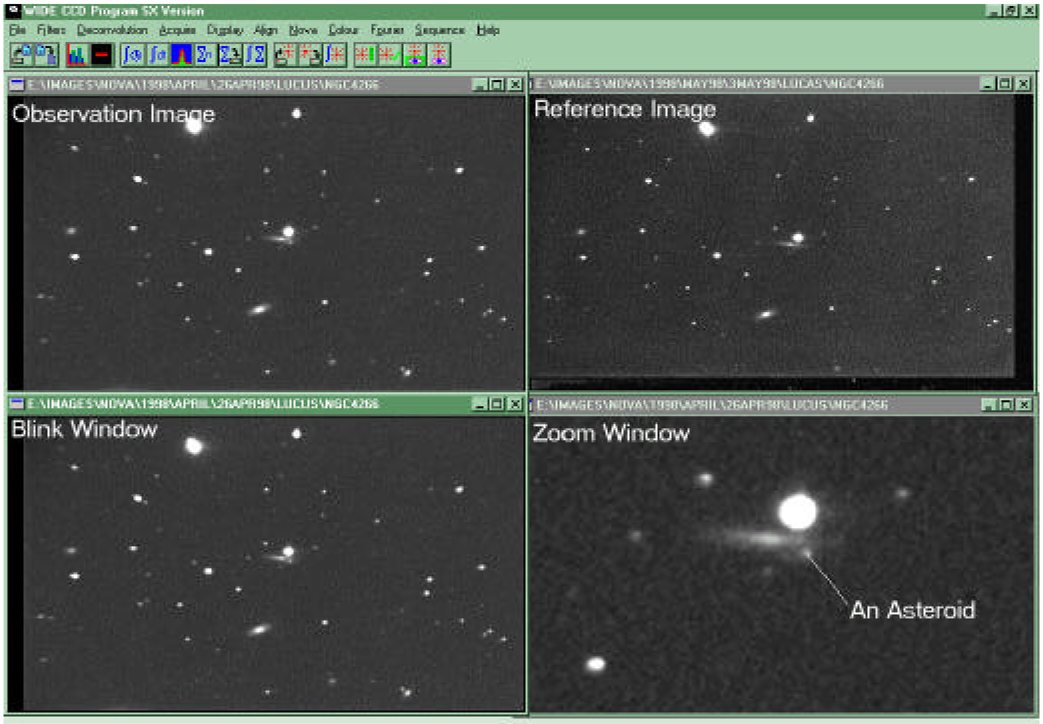


Figure 3 – An example of the system.

### Off-line system.

The system can be run without being connected to the telescope. Instead of reading the image from the telescope camera, the image is read from the hard disk. In this mode, the user must tell the system to move onto the next image by clicking a mouse button. This mode is very useful for checking the previous nights patrol, just in case an object of interest was missed while at the telescope.

### Report generation

Since all the data necessary to generate the monthly reports, is stored with the imagery, a facility has been incorporated that will automatically generate the monthly patrol report required by Guy Hurst. The routine writes the data as a text file that can be imported into Microsoft Excel.

### System performance

An example of the system performance is summarised in the table below:

| | |
|---|---|
| Typical time for moving the telescope | 5 seconds |
| Telescope settling time | 5 seconds |
| Image integration time | 30 seconds |

| | |
|---|---|
| Image download and save time | (2 seconds) |
| Total time | 40 seconds |
| Hourly acquisition rate | 90 images per hour |

The acquisition rate stated in the above table is close to the actual rate obtained when using the system. Since about 90 galaxies per hour can be acquired, the acquisition of one hundred galaxies becomes straightforward. The main limiting factors now become the number of dark hours and the British weather (we live near Hereford not to far from the Welsh border and we seem to get more than our fair share of cloud!).

**Conclusions & future enhancements**

This article has described a system for the automatic acquisition of supernova patrols. The system allows supernova hunters to concentrate on searching the images for evidence of new features, while a computer controls all other tasks. With this system, it is relatively straightforward to acquire over one hundred galaxy images in one night.

The author has also tried writing a routine that will automatically detect differences between the reference image and the observation image. Although registration (alignment) between the images can be accomplished accurately, when reference image is subtracted from the observation image, the stars leave a large residual. The reason for this residual is associated with the point spread function (PSF) of the stars. Under different observing conditions, differences in focus, and tracking, a star's PSF will differ from one night to the next. Hence, when the difference between the two images is calculated a residual remains. The author is currently working on how to normalise the stars PSF. When this works the system will then be fully automatic and able to detect and report anomalies without any human intervention.

**Acknowledgments**

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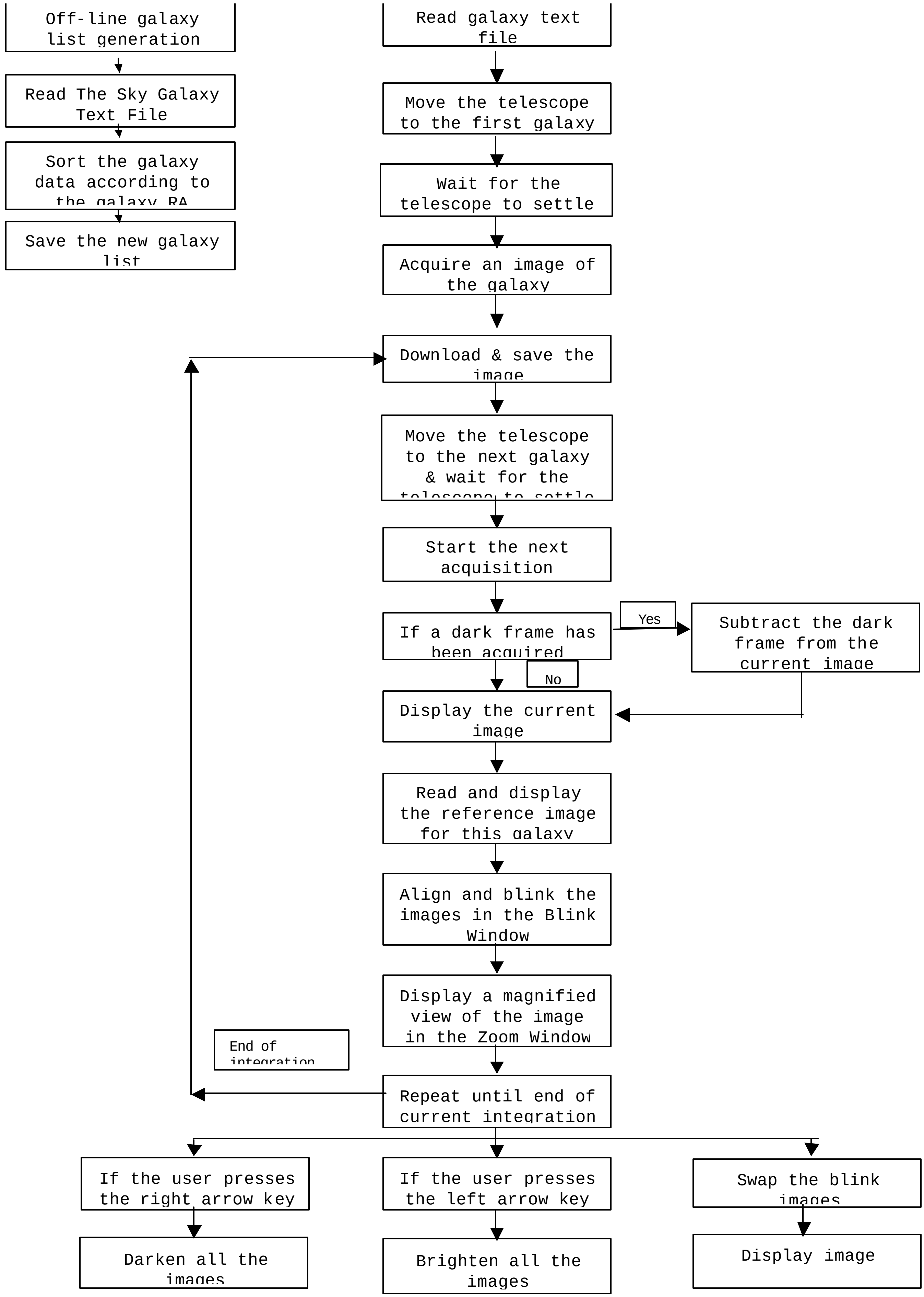


Figure 1 - Simplified control flow diagram