6th June- 29th July 2011 Polar Bear Telescope RKJ

Report

Introduction and General Points

Over the past two months we have managed to create a database for the data from the three cameras and carry out some initial analysis on a few stars. There may be problems with the photometry and astrometry which may need to be investigated further.

All of the files relating to the database such as stilts files and log files are located in the directory `/home/rkj/mystilts` and all files relating to any analysis, including plots, are located in the directory `/home/rkj/analysis`. Files containing data extracted from the database have the form `star1234.csv` and using **vi** these have been converted to a format suitable for use in programs such as **dipso**.

Database Creation

We have created a large database in **PostgreSQL** which contains three tables. The largest table, the object database, contains the information from the `.phot` files. The second table (the image database) contains the information from the `.fits` files, while the final table simply contains the USNO catalogue which was used to identify the stars and can be used to find specific stars.

The main code to create the database can be found at `/home/rkj/mystilts/stilts.sh`. First the Julian date, fractional time, camera number, etc. are calculated before the USNO catalogue and the `.phot` file are read into stilts which performs the cross matching. The error parameter has been set to 300 arc seconds. Although this will cause false matches a lower value would have excluded too many valuable data points (this was investigated by using **topcat** to perform matches between two stars using different error values and plotting the results). After the cross matching the outputted file is piped into stilts again where the columns edited and the file is converted to csv format. Another csv file is created for the image database and then both csv files are read into the appropriate table in the database .

N.B. The case statement which sets the data_disk will need to be updated whenever the disk changes and the exposure time value also needs to be changed manually!

The Object Database – pbtphot_v2:

- This contains the following columns and data types:
  - number (integer) – this is the number the star has been assigned in the indexed USNO catalogue and is the most useful way of extracting all of the data for a star from the database.
  - image_id (integer) – we have created this unique image identifier for each image by combing different pieces of information. First we take the camera number (camera 126=1, camera 128=0 and camera 129=-1) then the integer part of the Julian date and the first five digits of the fractional part of the Julian date, i.e. image_id=cjjjjfffff. Note that the time and date used in the image_id are calculated using the 'obs' times obtained by subtracting 37secs from the raid time.
    Example: The image file 129_20090109_182930.fit has an image_id -1484177006
  - ra and dec – modular arithmetic is used to convert to a small integer.
  - mag (small integer) – Added 21 and then multiplied by 1000 to get a positive integer.

  - mag_error (small integer) – Multiplied by 1000 to convert to an integer.

The Image Database – pbtimage_v2

- This is the table contain the information from .fit files such as the data disk, folder, etc. as well as various time and date information.
  - The spocdate and spoctime are taken from the image header.
  - The raid time comes from the file name.
  - To make the Julian date a small integer we have subtracted 2450000.

The usno_catalogue table contains the file `/data/usno_catalogue/usno_edited.csv`. This file was created after duplicate entries were discovered in the previous versions, which then caused duplicates in the database. The original tables, created with the older catalogue file, can now be deleted.

To date all of 2009 has been processed. The beginning of 2010 (`stilts_10A`) is currently being processed.

There are a few minor points worth noting regarding the database. **PostgreSQL** removes unnecessary zeros, which means it also removes the zero at the beginning of the image identifiers from camera 128. The database does not guarantee sorting, so when executing a query where you would like the results in a particular order it is worth adding an ORDER BY [column name] command. Once of all the data has been processed should 'bad' data, i.e. entries with large flag numbers, be removed?

Extracting Data From The Database

Extracting data from the database is quite simple. To extract the data for an individual star (in this case number 22000) the following command can be used from the terminal window:

```
psql PBT -c "COPY (SELECT * FROM pbtphot_v2 WHERE number=22000) TO
STDOUT WITH CSV;" >star22000.csv
```

If you want to find the number of a specific star it is easiest to search the usno_catalogue table using simple expressions. e.g. to find a red star with ra=291°, dec=85.36° and magnitude=9.6 you could use something like this:

```
SELECT * FROM usno_catalogue WHERE ra > 289 AND ra < 294 AND dec > 83
AND dec <87 AND r1 > 9.3 AND r1 < 10;
```

This should quickly return only a few possible matches. Having now obtained the catalogue number, the data for the star can be extracted using the command above.

Pbtphot_v2 is already an enormous table with over 900,000,000 entries meaning executing queries is very slow. Extracting all of the data for a star takes around 5 minutes and this will only get worse as the table is populated with more data. Perhaps there is a way to improve this? [insert Geert]

Initial Analysis

We have tried to carry out some basic analysis on a few stars. When using **dipso** the csv files obtained form the database will need to be edited (using **vi**) first. Namely, creating a column with the camera numbers 1,2,3 and converting ',' to ' '. By sorting the file, the ranges of each camera can be obtained which will be useful when reading into **dipso.**

N.B. I have been doing the editing using a global replace which will cause problems if by coincidence the string appears elsewhere. This is a big problem with lower numbered stars where it becomes quite likely that the string will appear in the middle of some rows.

Before using **dipso**,we need to find a comparison star. Read the USNO catalogue into **topcat** and plot the Ra and DEC, then add the magnitude as an auxiliary axis. Once you have found your star on the plot it is easy to choose a nearby, brighter star. This will provide the number of the comparison star, allowing you to extract it from the database.

Initial plots made using **gnuplot** showed a zero point shift between the three cameras, which has not been fully explained, and a large amount of scatter in the data. The zero point shift can be removed with **dipso** by finding the mean values and subtracting.

A few pairs of stars where read into **dipso** and we produced a plot of the transform for each camera and the magnitude against time for a few nights. By subtracting the y-values of one star from the other we can get a differential magnitude for each camera. Looking at the first few Scargle Periodogram plots it seems as if camera 2 may be the noisiest. This is perhaps something which could be explored more thoroughly.

N.B. Nights in early 2009 often have no data after midnight (problem with the data reduction process?). So don't be concerned if a plot seems to only cover half the night.

Red Carbon Star: **HD 187216** (number 22214)

I selected star number 22000 as the comparison star using **topcat**. When the differential magnitude is plotted for camera 1 a separate band is seen between 1.5-2.0 mag. Here the star is being misidentified by **stilts**. Camera 1 has more data than the other two and the star is not misidentified in other cameras.

I also plotted the y-position against the x-position for each camera. There are rings in the plot (use *expand*). These may be caused by camera shifts.

By plotting the y-position and x-position for the carbon star and the comparison star in camera 1 and zooming in you can find the points where the path of the carbon star jumps.

Some very interesting things happen when the right ascension and declination are plotted for the two stars. The plot for the carbon star has a strange diagonal line cutting through the ellipse, however there are still some points on the other side of this line. The data for camera 1 is clustered in the centre, unlike the data for the other two cameras. A solution for this would be to take the median values of the Ra and Dec and simply remove any points outside a given radius, since it is these points which are likely to be other stars.

The equivalent plot for the comparison star would be a nice ellipse except for the fact that the bottom half is missing! There are no points below ≈84.985°. This must be happening in **stilts** and will need to be investigated.

Algol Type Binary Stars

I have managed to identify the first three of these stars, however the fourth star (TY UMi) could be one of three stars in the usno catalogue and I was unsure of which was the best choice. I have also selected comparison stars for the first three, however this was a bit tricky for the third star as there are no brighter stars nearby. I choose one that was of a similar brightness. I have extracted the data for all the stars and the comparisons, including the three possible candidates for the final star.