Creating updated, scientifically-calibrated mosaics for the RC3 Catalogue

1. Introduction

The Third Reference Catalog of Bright Galaxies (RC3) (de Vaucouleurs et al. [3]) contains a complete listing of 23,022 galaxies with D_25 apparent major isophotal diameter greater than 1 arcminute and with a total B-band magnitude greater than 15.5. There has been existing literature on this subject using data from the Sloan Digital Sky Survey(SDSS). Hogg and Blanton made g,r,i colored images by using data from the SDSS DR6.[1] The EFIGI catalog (Baillard et al. [1]),dedicated to studying morphology of galaxies , also obtained a subset of 4458 RC3 FITS and color images by discarding artifacted or missing data by visual inspection and using SDSS DR4 data and . We perform the mosaicing procedures on the whole RC3 catalog using an automated positional update algorithm on the most recent SDSS DR 10 imaging data. In addition, we designed a mosaicing pipeline that creates scientifically-calibrated mosaics, color-band images, as well as a set of updated position values, which can be easily suited for existing surveys such as 2MASS, DSS, or new imaging data release from Dark Energy Survey and Large Synoptic Survey Telescope for larger sky coverage and multiband images.

2. Automation Program

2.1. Positional Inaccuracy in RC3 Catalog

The principle motivation behind the automation algorithm is to resolve the problem of centering the galaxy and finding RC3 galaxy in an image. Initially using the standard mosaicing steps in Montage, we obtained many images whose galaxy are off center or can not found, we found that this was not due to wrong coordinate frame converison/ equinox precession issue since the effects should be negligible in terms of centering a galaxy but due to the inherent inaccuracy of the positions given by the RC3 Catalog. The J2000 Two different levels of precision shown in RC3: HH MM.m, DD MM for the inaccurately known positions(Accuracy of 1-2 arcmin), and HH MM SS.s, DD MM SS for the more accurately known positions (Accuracy of 5-8 arcsec)

2.2. Algorithm

The rc3 class creates an rc3 object containing its "basic info" [2] for each galaxy in the RC3 catalog. The practical purpose of the class (other than the use of OOP that actually makes sense) is to keep tract of the number of iterations in the recursive step using the instance variable num_iterations.

Some parts of the program needs to be adjusted for survey-specific , but the core concept (and bulk of the code) should stay the same.

2.3. Parameters of Interest

We have decided to record the The Catalogue of Principal Galaxies (PGC) number to idenitfy the RC3 galaxy of interest for cases of source confusion, since every RC3 galaxy has a unique PGC number.

2.4. Technical Details

As the usage of Python for astronomy become more popular in recent years, we wrote the program in Python 2.7.6 so that the pipeline support future datasets. It uses IPAC's Montage [4] using the AstroPy Montage wrapper[3]. The final g,r,i image is created using Astromatic STIFF [2] . Our choice of program reflects best feature from both program : STIFF provides the flexibility of changing many variables for the final g,r,i; Montage creates scientifically-calibrated images by retaining astrometric accuracy during image reprojection. The use of two different program in the mosaicing step is due to Montage's ability to create scientifically-calibrated mosaic FITS, but STIFF provided more flexible parameters for combining all bands into color images, so we get the best of both worlds. The STIFF setting needs to be adjusted for each survey depending on specs on the telescope's CCD dependent parameters such as imaging bands. (?) The source extraction is done using SExtractor (version (?) and above is sufficent to do the job) If the mosaicing field is chosen correctly, then SExtractor's skylevel estimation is fairly accurate.

2.5. Getting the Data

2.5.1. Search

Figure out how to convert positional values (ra,dec) to record-keeping parameters dependent on the survey's telescope. (tiles, frames...etc) [4] Usually this step can be done using the SQL search. Most surveys have an API

[1] `http://cosmo.nyu.edu/hogg/rc3/`

[2] ra,dec,radius, pgc

[3] `http://www.astropy.org/montage-wrapper/`

[4] Since SDSS images are taken in drift-scan mode, we need the run,camcol,field values to acess each iamge frame

that enables you to acess data using SQL querys so that the mosaicing program can interact with so that it doesn't have to click buttons or type in textboxes in the web GUI.

3. Algorithms

4. Pipeline

4.1. Class Hierarchy

5. Result from SDSS run

There are _ RC3 galaxies within the footprint. on average the program processes 1.21 galaxies per minute

5.1. Known Errors

Even though a series of exception handling and error prevention mechanisms were put in place,

- mProjectExec is the montage Mosaic procedure that creates the reprojected image from the raw FITS files. Sometimes reprojected images are not created even when Montages' debug statement clearly shows that the reprojection was successful and table and header files are corrupted. This results in an error in later mosaicing steps. We have implemented error prevention mechanism to ensure that mosaic procedures terminates correctly in such cases and wrote the problematic galaxy into failed_projection, which can be examined later.
- Sometimes in the step "apply background model to images" takes a long time and produce huge files in coordir $\tilde{()}$

5.2. Performance

We accelerate the mosaicing process by performing the recursive algorithm on only a single band FITS file designated as `best_band`, and then mosacking all bands only once per object. For SDSS, we use the image obtained by the r band filter since transmission curve in Stoughton et al. [5] shows that r band has the highest quantum efficiency. Most of the computation time is spent on downloading the raw FITS files from the survey's specific server. Therefore, even though Montage's (Drizzle Algorithm?) performance scales with number of processor on a cluster (Jacob et al. [4]) the process would not be significantly sped up even if ran in parallel. This process would be significantly sped up if the investigator already has imaging data stored locally on a disk or have access to running the mosaic program alongside the survey's datacenter. We have designed our class hierarchy such that this can be written as a subclass of `Server` with user-defined details of where the images are stored. The Montage mBgExec takes a long time .

6. Possible Uses of Data Product

Can be incorporated in the photo pipeline in future survey to make pretty rc3 images. with larger focal plane more photon such as the LSST saturation especially with the DSS data, full coverage of the sky map out where bright objects are.

The scientifically calibrated FITS images can be used as for indivudual studies . It can be used for improved astrometry (as we did) in updating the catalog. Can also do photometry to determine galaxy property

Another possible usage is to combine the calibrated mosaics into multiband color images with mosaics from single/double band surveys such as POSS-I and GALEX.

7. Conclusion

Can talk about here how LSST and future telescope can mask theses so that image not saturated

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