3-D Source Finding Challenges in the Era of "Big Data"

Tobias Westmeier (ICRAR/UWA) and the SoFiA collaboration



International Centre for Radio Astronomy Research





Governmen Department of Office of Sci

Government of Western Australia Department of the Premier and Cabinet Office of Science



SoFiA Source Finding Application

Cape Town, 02/02/2016



- ★ Source Finding Application
 - Pipeline for source finding and parameterisation of HI data cubes
- ★ SoFiA website
 - https://github.com/SoFiA-Admin/SoFiA/

★ Programmers and contributors

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 Martin Meyer (ICRAR)
 Bärbel Koribalski (CSIRO)
 Lister Staveley-Smith (ICRAR)
 Hélène Courtois (Lyon)
- ► Thank you to SoFiA users for their feedback





Modern graphical user interface

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- Modern graphical user interface
- Extensive user manual and tutorial

SoFiA Tutorial – 3 Basic Source Finding Run SoFiA edited this page on 7 Dec 2015 · 24 revisions

3 Setting up a basic source finding run

This section Illustrates how to run SoFIA on the H I data cube provided for testing purposes on the SoFIA wiki at https://github.com/SoFIA-Admin/SoFIA/wiki/SoFIA-Test-Data-Set. The settings for this example are provided in the file SoFIA_Tutorial_Section_3_S+C.par which can be directly loaded into SoFIA by selecting "Open..." from the "File" entry in the menu. Alternatively, all parameters can be set manually by following the instructions below.

Note

In order to get more information about a particular parameter setting, you can first click on the "What's this?" icon in the tool bar (or the corresponding item in the help section of the menu bar) and then on the corresponding field or button. This should open a tool tip with some basic information about the parameter and its possible values.



3.1 Selecting the input data cube

Navlgate to the first tab ("**Input**"). In the "Input Data Products" section click on the "Select..." button next to the "Data cube" field. This will open a file selection window in which you can select and open the input data cube named sofiatestcube.fits. The full path of the data cube should now appear in the text field, as shown below in Fig. 2. In addition, the small icon next to the section heading should have turned from red to green, indicating that an input data cube has been specified.

put	Input Filter	Source Finding	Merging	Parameterisation	Output Filter	Output
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iles a	and settings					
	Data cube: 🖊	home/SoFiA_Test/s	ofiatestcube	e.fits		Select



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- Modern graphical user interface
- Extensive user manual and tutorial
- Multiple source finding algorithms
 - Basic threshold finder
 - Smooth + Clip finder (Serra et al. 2012)
 - CNHI finder (Jurek 2012)
 - 2D-1D wavelet finder (Flöer & Winkel 2012)







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- Different mask optimisation algorithms





Right Ascension





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- ► Reliability calculation / filtering (Serra et al. 2012)
- ASCII and VOTable output

	SoFiA
Source	Finding Application

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26	~	wm50	\$26	Float	chan		spect.line.width	float
27	~	ra	\$27	Float	deg		pos.eq.ra	float
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- Different mask optimisation algorithms
- Busy Function fitting (Westmeier et al. 2014)
- ► Reliability calculation / filtering (Serra et al. 2012)
- ASCII and VOTable output
- Wide range of output data products

	SoFiA
Source	Finding Application

es and settings					
Base name:					
utput directory:					Select
ource catalogue: 🕱 A	SCII 🗌 VO table	SQL			
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★ SoFiA test cube

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- ► WSRT cube from KILAS^{3D} survey (Serra et al. 2012)
- Using S + C finder with 5σ threshold



3-D Source Finding Challenges in the Era of "Big Data"



SoFiA test data cube





★ SoFiA test cube

Problem: edge-on galaxy split into two sources





SoFiA test data cube

• Let's use a lower threshold of 3σ ...





★ SoFiA test cube

Problem: too many false detections





SoFiA test data cube

Solution: reliability filtering





★ SoFiA test cube

► All three galaxies detected above 90% reliability threshold



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1	96	668	1	18.8552	6.3744	84.3352	
2	63	2906	1	21.3729	15.8734	31.6328	
3	38	2873	1	7.5632	5.5275	165.136	
4	57	75	0.882118	2.9334	2.0033	47.9229	
5	94	44	0.071035	3.8123	1.3081	56.3058	
6	8	41	0.846014	3.0517	1.3232	129.816	
7	53	40	0.830608	3.7634	1.7965	58.026	
8	86	528	0.8173	5.2782	2.4251	36.3286	
9	17	27	0.774734	4.4023	1.4041	115.779	
10	11	36	0.760476	2.3143	1.9623	118.461	
11	97	539	0.759669	4.5809	2.7959	160.906	
12	98	448	0.678576	6.2555	2.4472	169.203	
13	18	101	0.634916	2.4558	2.0636	146.367	
14	78	47	0.560401	2.5135	1.6798	118.946	
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SoFiA test data cube







★ SoFiA test cube

► Mask optimisation for accurate parameterisation





SoFiA test data cube





★ SoFiA test cube

Examples of SoFiA data products







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3-D Source Finding Challenges in the Era of "Big Data"

1400



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	Cape Town, 02/02/2016 3-D 3	Source Finding	Challenges in	the Era of	"Big Data"			20	

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- ★ Improving reliability
 - ► Assumptions:
 - Genuine **SOURCES** have positive flux
 - Flux distribution of **noise** is symmetric about zero
 - ► Compare density of pos. and neg. detections in parameter space → reliability of detections
 - ► Serra et al. 2012, PASA, 29, 296





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2	63	2906	1	21.3729	15.8734	31.6328					
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13	18	101	0.634916	2.4558	2.0636	146.367					_
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ICRAR

Era of "Big Data"

- ★ Improving reliability
 - ▶ $3-D \rightarrow 4-D$ parameter space
 - $N_{\text{pix}} \Delta z SNR_{\text{int}} SNR_{\text{peak}}$



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ICRAR

Era of "Big Data"

- ★ Improving reliability
 - ► $3-D \rightarrow 4-D$ parameter space
 - $N_{\text{pix}} \Delta z SNR_{\text{int}} SNR_{\text{peak}}$
 - Improvement of filter used for smoothing in parameter space
 - Narrower filter in Δz direction

More at the next busy week...





★ Parallelisation of SoFiA

- ► Limited memory → dissection of data into manageable chunks
- Limited time \rightarrow speed-up of time-critical algorithms





- ★ Dissection of cube
 - Split into *m* sub-cubes with small overlap region around them:
 - Avoid slicing through sources
 - Buffer for filtering, e.g. smoothing
 - Westerlund & Harris 2014, PASA, 31, 23



Westerlund & Harris (2014)





★ Dissection of cube

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★ Parallelisation of time-critical algorithms

- ► CPU-based:
 - OpenMP Compiler instructions Easy to use; no Python support
 - MPI Message-passing library More complicated; available for Python
- ► GPU-based:
 - CUDA Parallel computing platform Based on C++; for Nvidia GPUs
 - OpenCL Parallel programming standard Based on C; for various devices

★ Speed-up of algorithms

- Optimisation of algorithms
- ► Conversion of Python modules to C/C++



Current Activities

★ Collaboration with *Sarah Blyth* and *Michelle Kuttel* (UCT)

- Parallelisation of SoFiA's S+C finder module
- ▶ Honours project of *Jarred de Beer*
- ★ Source finding busy week
 - ► 8-12 February 2016, ICRAR, Perth
 - Main tasks: parallelisation and reliability
- ★ Volunteers welcome
 - Algorithm optimisation and parallelisation
 - Ideas for new techniques

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SoFiA Download and Information

★ For more information

- ► SoFiA website on GitHub:
 - https://github.com/SoFiA-Admin/SoFiA/
- ► SoFiA tutorial:
 - https://github.com/SoFiA-Admin/SoFiA/wiki/SoFiA-Tutorial
- ► SoFiA paper:
 - Serra, Westmeier, Giese, et al., 2015, MNRAS, 448, 1922
- ► SoFiA mailing list:
 - sofia-request@atnf.csiro.au with "subscribe" in the e-mail body (subject will be ignored)

SoFIA-Admin / SoFIA	guests o 🔠 Wiki 🔶 Pulse 🔐	© Watch	10 ★ Star	6 ¥ Fork 3	
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Cape Town, 02/02/2016