Procedure to install Pulsar software repository and FRB detection pipelines

Vinay Bharambe

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The below document includes installation process for Basic pulsar software repositories to finally successfully install SPANDAK (PulsarSearch) by Dr. Vishal Gajjar. This includes compilation and building of these repositories for **Python 2.7** base. Also, procedure to install other softwares on Python 3 is given.

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1. System specifications

While the below softwares can be installed on any Linux system, for having easiest steps to install SPANDAK I've used x86 based system with Ubuntu 19.04. This is because Ubuntu 19.04 was the last system to support Python 2 (must for SPANDAK) and pip as default. Also, latest version of gcc encounters compilation errors with few softwares and many more things.
An equivalent installation can be done with Anaconda based Python installations on Ubuntu 22.04. But, you may have to downgrade your gcc version manually to gcc-9 or below and then update the alternatives for gcc. An older version of swig will also be necessary in such installations. See the Other software section

2. Softwares to be installed

1. FFTW

2. CFITSIO

3. PSRCAT

4. TEMPO

5. PRESTO (Scott Ransom)

6. PGPLOT

7. TEMPO2

8. PSRCHIVE

9. DSPSR

10. CUDA 12.1

11. Dedisp

12. PSRDADA

13. Heimdall

14. Sigpyproc (Ewin Barr)

15. Sigproc (Mike Keith)

16. SPANDAK / PulsarSearch (Vishal Gajjar)

The software below in the list depends on the softwares above it (except a few). Hence, it is recommended to follow the order for installation.

3.   Setting up environment variables :

In order to install the softwares, we first need to setup several environmental variables for path of the softwares, path to the libraries and location of installation.
The above task can be done be editing /home/$USER/.bashrc file. Open the .bashrc file in any text editor and add below lines at the end of the already written text.

```
#PATH TO THE MAIN PULSAR SOFTWARE DIRECTORY
export ASTROSOFT=/home/vinay/pulsar_repo

#OSTYPE
export OSTYPE=linux

#PSRCAT
export PSRCAT_RUNDIR=$ASTROSOFT/psrcat_tar
export PSRCAT_FILE=$ASTROSOFT/psrcat_tar/psrcat.db

#TEMPO
export TEMPO=$ASTROSOFT/tempo

#TEMPO2
export TEMPO2=$ASTROSOFT/tempo2/T2runtime

# PGPLOT
export PGPLOT_DIR=/usr/lib/pgplot5
export PGPLOT_DEV=/xwindow


#PRESTO
export PRESTO=$ASTROSOFT/presto

#LD_LIBRARY PATH
export LD_LIBRARY_PATH=/usr/lib:/usr/lib/x64_64-linux-gnu
    :$PGPLOT_DIR:$ASTROSOFT/lib:$PRESTO/lib:$PRESTO/lib64
    :$ASTROSOFT/sigpyproc/build/lib.linux-x86_64-2.7
    :/home/$USER/pulsar_repo/lib
```

```
#PATH
export PATH=$PATH:$ASTROSOFT/bin:$PRESTO/bin:$PGPLOT_DIR
    :$PRESTO/python:$ASTROSOFT/bin/psrchive:/bin:/sbin
    :/usr/sbin:/usr/local/sbin:/home/$USER/.local/bin
    :/usr/local/cuda/bin:$ASTROSOFT/PulsarSearch


export PKG_CONFIG_PATH=$ASTROSOFT/cfitsio-4.2.0

export LD_RUN_PATH=$ASTROSOFT/lib

export PYTHONPATH=$PYTHONPATH:$PRESTO/lib/python
    :$ASTROSOFT/lib/python2.7/site-packages
```

If you find few of the above environment variables unnecessary for your build, you may delete them. But generally it does not hurt to have some of the extra being set.

Save the .bashrc file and restart the terminal. You may also use " source ∼/.bashrc" command

The above edits can also be found at https://github.com/VinayBharambe/pulsar_repo

4.   Dependencies

We'll be installing basic dependencies required for the below softwares from apt manager or pip for python libraries. We'll be installing other dependencies later which are not installed directly available but can be built from source.

If you want to install all these softwares on Python3, replace all the below python packages with python3. For e.g. python3-scipy.

Caution : SPANDAK needs Python 2. See Section 5. Other softwares can be built with Python3.

```
sudo apt install -y ftp wget csh cvs emacs build-essential git m4
sudo apt install -y gsl-bin libgsl0-dev gfortran fort77 python-dev
```

```
sudo apt install -y python-numpy python-scipy python-matplotlib
sudo apt install -y python-sympy python-nose ipython autoconf
sudo apt install -y automake libtool flex bison swig cmake
sudo apt install -y libpng-dev libglib2.0-dev libgd-dev libltdl-dev
sudo apt install -y libltdl7 libblas3 liblapack3 libblas-dev
sudo apt install -y liblapack-dev libxext-dev gnuplot gnuplot-x11
sudo apt install -y libx11-dev xterm xpdf imagemagick htop screen
sudo apt install -y gpicview libopenmpi-dev openmpi-bin mpich
sudo apt install -y libmpich-dev libhdf5-openmpi-dev latex2html
sudo apt install -y libhdf5-mpich-dev default-jre default-jdk
sudo apt install -y libfftw3-bin libfftw3-dev libcfitsio-bin tcsh
sudo apt install -y python-pip librdmacm-dev libboost-all-dev
```

5.   Dependencies for SPANDAK

SPANDAK / PulsarSearch is based on **Python 2**. Hence most important requirement is active Python 2 environment. This can be done by either using Python 2 from Ubuntu or by using anaconda. All the procedure in this manual are according to Ubuntu 19.04 as it is easy install and has Python 2 as default python. One may refer to below article for setting up Python 2 in Anaconda https://docs.anaconda.com/anaconda/user-guide/tasks/switch-environment/. Other than that SPANDAK needs below softwares.

1. PRESTO 2.2 (Scott Ransom) along with its Python interface.
   $\longrightarrow$ PRESTO depends on FFTW, CFITSIO, TEMPO and libglib2.0-dev.

2. PSRCHIVE along with its Python interface
   $\longrightarrow$ PSRCHIVE depends TEMPO2 along with others

3. Heimdall (Transient Detection Pipeline)
   $\longrightarrow$ Heimdall requires CUDA, Dedisp, PSRDADA installation and libboost-all-dev.

4. Sigproc (Mike Keith), Sigpyproc (Ewin Barr) and Gnuplot-py (Michael Haggerty)
   $\longrightarrow$Python 2 along with pip (python2) is sufficient.

5. SPANDAK github repository.

6. Pulsar Software repositories

The below categorization is only to make installation possible with minimum dependent softwares and not to categorize the pipelines as Pulsars or FRBs.
The general rule of installing any software will be
⟶ Download or clone its source code
⟶ Change directory to the folder
⟶ Using bootstrap or prepare if needed
⟶ Configure the program for our specifications and setting up the installation location
⟶ 'make' command
⟶ 'make install' command.

```
cd /home/$USER
mkdir pulsar_repo

cd pulsar_repo
```

6.1   FFTW

Updated software can be downloaded from FFTW website.

```
wget ftp://ftp.fftw.org/pub/fftw/fftw-3.3.10.tar.gz
tar -xvf fftw-3.3.10.tar.gz
```

```
cd $ASTROSOFT/fftw-3.3.10
./configure --prefix=$ASTROSOFT --enable-float --enable-threads
    --enable-shared CFLAGS=-fPIC FFLAGS=-fPIC

make check
make install
make clean
```

Note : `"./configure --prefix=$ASTROSOFT --enable-float --enable-threads --enable-shared CFLAGS=-fPIC FFLAGS=-fPIC "` is a single command and not two. It is written on two lines for convenience of reading to the reader.

6.2 CFITSIO

The updated versions can be downloaded from NASA website.

```
wget http://heasarc.gsfc.nasa.gov/FTP/software/fitsio/c/cfitsio-4.2.0.tar.gz
tar -xvf cfitsio-4.2.0.tar.gz
```

```
cd $ASTROSOFT/cfitsio-4.2.0
./configure --prefix=$ASTROSOFT CFLAGS=-fPIC FFLAGS=-fPIC
make shared
make install
make clean
```

6.3 PSRCAT

Latest PSRCAT can be found on ATNF website.

```
wget http://www.atnf.csiro.au/people/pulsar/psrcat/downloads/psrcat_pkg.tar.gz
tar -xvf psrcat_pkg.tar.gz
```

```
cd $ASTROSOFT/psrcat_tar
source makeit
cp $ASTROSOFT/psrcat_tar/psrcat $ASTROSOFT/bin
```

One known error while doing "source makeit" is with higher version of gcc. For gcc-9 and below you'll not encounter such error. So, if you are using higher version of gcc, consider downgrading gcc with gcc-9 or below and update alternative (preference) of gcc to gcc-9. See the other software section for it.

6.4 PGPLOT

PGPLOT can be built from the PGPLOT source code. But for most of the Debian based system apt manager provides a nice package.
The below process is from apt manager and $PGPLOT_DIR environment variable and others are set according to it. Make sure you have set $PGPLOT_DIR and $PGPLOT_DEV properly.

```
sudo apt install pgplot5
```

6.5 TEMPO

The NANOGRAV github repository have updated source code of TEMPO. Make sure you have set $TEMPO environment variable properly.

```
git clone https://github.com/nanograv/tempo.git
cd $ASTROSOFT/tempo

./prepare
./configure F77=gfortran --prefix=$ASTROSOFT CFLAGS=-fPIC FFLAGS=-fPIC
make
make install
```

6.6 PRESTO (Scott Ransom)

To install PRESTO successfully, you must have FFTW, CFITSIO and TEMPO installation. Also, you'll need libglib library which is available on apt manager as **libglib2.0-dev**. For Python interface of PRESTO you'll require astropy which can be installed from pip. Make sure you have $PRESTO environment variable set and the name of the folder is "presto". For more information visit PRESTO github page. **For PRESTO 2.2 (Based on Python 2.7 which is must for SPANDAK)**

```
wget https://github.com/scottransom/presto/archive/refs/tags/v2.2.tar.gz
tar -xvf v2.2.tar.gz
mv presto-2.2 presto
```

```
cd $PRESTO/src
make makewisdom
make prep
make
make clean
```

Procedure to compile python interface for PRESTO 2.2. **For SPANDAK installation PRESTO python interface is must.**

```
cd $PRESTO/python
make
```

For PRESTO 4.0 (Latest and based on Python 3)

```
git clone https://github.com/scottransom/presto.git
cd $PRESTO/src
make makewisdom
make prep
make
make clean
```

To compile python interface for PRESTO 4.0

```
cd $PRESTO
pip install .
```

6.7 TEMPO2

Make sure $TEMPO2 is set properly. Latest TEMPO2 can be cloned from below link.

```
git clone https://bitbucket.org/psrsoft/tempo2.git

cd $ASTROSOFT/tempo2
./bootstrap
./configure F77=gfortran --prefix=$ASTROSOFT --with-cfitsio-dir=$ASTROSOFT
    --with-fftw3-dir=$ASTROSOFT CFLAGS=-fPIC FFLAGS=-fPIC
    CXXFLAGS="-I$ASTROSOFT/include -I$PGPLOT_DIR" LDFLAGS=-L$PGPLOT_DIR
make
make install
make plugins
make plugins-install
make unsupported
make unsupported-install
make clean
```

6.8 PSRCHIVE

To install PSRCHIVE along with other softwares TEMPO2 installation is must. For build-ing PSRCHIVE with shared libraries which is must for building PSRCHIVE python in-terface "- -enable-shared" option is must. **SPANDAK installation needs PSRCHIVE python interface.**

```
git clone git://git.code.sf.net/p/psrchive/code psrchive
```

```
cd $ASTROSOFT/psrchive
./bootstrap
./configure F77=gfortran --prefix=$ASTROSOFT --with-cfitsio-dir=$ASTROSOFT
    --with-fftw3-dir=$ASTROSOFT --enable-shared CFLAGS=-fPIC FFLAGS=-fPIC
make
make install
make clean
```

On running configure script, if you receive a warning to downgrade SWIG version. Please refer to Other software section of this document.

6.9 DSPSR

With current DSPSR versions you don't need to edit backends.list it is automatically done in bootstrap. Latest code can be found on the below link.

```
git clone git://git.code.sf.net/p/dspsr/code dspsr

cd $ASTROSOFT/dspsr
./bootstrap
./configure --prefix=$ASTROSOFT --with-cfitsio-dir=$ASTROSOFT F77=gfortran
    CFLAGS=-fPIC FFLAGS=-fPIC LDFLAGS=-L$PGPLOT_DIR
make
make install
make clean
```

7.   FRB repositories

7.1   CUDA installation

For installation of FRB repositories NVIDIA's CUDA installation is must. Also having Boost libraries and RDMACM libraries is recommended. CUDA installation is a time consuming and heavy process. CUDA can only be installed on NVIDIA GPUs of certain series. Before installing CUDA's latest version one must check if the GPU being used is supported by latest CUDA version. I'll be installing CUDA 12.1 on NVIDIA GTX 1650. I'll be using Ubuntu 19.04 version. Minimum 30 GB of free disk space is recommended. Refer to the below documentation for more details.

```
wget https://developer.download.nvidia.com/compute/cuda/repos/
    ubuntu1804/x86_64/cuda-ubuntu1804.pin

sudo mv cuda-ubuntu1804.pin /etc/apt/preferences.d/cuda-repository-pin-600

wget https://developer.download.nvidia.com/compute/cuda/12.1.0
    /local_installers/cuda-repo-ubuntu1804-12-1-local_12.1.0-530.30.02-1_amd64.deb

sudo dpkg -i cuda-repo-ubuntu1804-12-1-local_12.1.0-530.30.02-1_amd64.deb
sudo cp /var/cuda-repo-ubuntu1804-12-1-local/cuda-*-keyring.gpg /usr/share/keyrings/
sudo apt-get update
sudo apt-get -y install cuda
sudo apt-get install nvidia-gds
```

Reboot the system after installation and check if CUDA is installed properly by typing "nvidia-smi" command.

7.2 Dedisp

For installation of Dedisp, CUDA installation is must. Also, type "nvcc - -help" and read
the gpu architecture supported. For e.g for my system "sm_60" is supported.
In the Makefile.inc change the "GPU_ARCH = sm_60". Also change the
"INSTALL_DIR = $(ASTROSOFT)" with a text editor.

```
git clone https://github.com/ajameson/dedisp.git

cd $ASTROSOFT/dedisp
make
make install
```

7.3 PSRDADA

For installation of PSRDADA, the installation of CUDA and Dedisp is must. Also having
Boost libraries and RDMACM libraries is recommended.

```
git clone git://git.code.sf.net/p/psrdada/code psrdada
cd $ASTROSOFT/psrdada

./bootstrap
./configure --prefix=$ASTROSOFT
make
make install
```

7.4 Heimdall

Heimdall needs Dedisp, PSRDADA and CUDA installation. Also having Boost libraries and RDMACM libraries is recommended.

```
git clone git://git.code.sf.net/p/heimdall-astro/code heimdall

./bootstrap
./configure --prefix=$ASTROSOFT --with-psrdada-dir=$ASTROSOFT
    --with-dedisp-dir=$ASTROSOFT --with-cuda-dir=/usr/local/cuda
make
make check
make install
make installcheck
```

For compiling Python scripts of Heimdall.

```
cd $ASTROSOFT/heimdall/Scripts
make install
```

Type "heimdall –help" for testing its installation.

For running trans_gen_overview.py and other scripts you need Python 2 environment and Gnuplot-py library. See other softwares section for Gnuplot-py installation.

8. Other softwares

For successful installation of SPANDAK, we need below 3 softwares Sigproc, Sigpyproc and Gnuplot-py. In case of a warning with SWIG while running configuration script of PSRCHIVE, SWIG should be downgraded to lower version.

8.1 SIGPROC (Mike Keith)

Mike Keith's version of Sigproc. Can be compiled separately from earlier softwares.

```
git clone https://github.com/SixByNine/sigproc.git

cd $ASTROSOFT/sigproc
./bootstrap
./configure --prefix=$ASTROSOFT --with-cfitsio-dir=$ASTROSOFT
    --with-fftw-dir=$ASTROSOFT F77=gfortran CFLAGS=-fPIC
    FFLAGS=-fPIC CPPFLAGS=-I$ASTROSOFT/include
    LDFLAGS="-L$ASTROSOFT/lib -L$PGPLOT_DIR -L/usr/lib/x86_64-linux-gnu"
    LIBS="-lX11 -ltempo2pred -lpng"
make
make install
```

8.2 Sigpyproc (Ewin Barr)

Ewin Barr's version of Sigpyproc.

```
git clone https://github.com/ewanbarr/sigpyproc.git

cd $ASTROSOFT/sigpyproc
pip install .
```

8.3 Gnuplot-py (Michael Haggerty)

This is a particular Python Gnuplot library which is needed for using Heimdall and SPANDAK python scripts.
It can be downloaded from https://sourceforge.net/projects/gnuplot-py/

```
wget https://altushost-swe.dl.sourceforge.net/project/gnuplot-py/
    Gnuplot-py/1.8/gnuplot-py-1.8.tar.gz
tar -xvf gnuplot-py-1.8.tar.gz

cd $ASTROSOFT/gnuplot-py-1.8
pip install .
```

8.4 Swig 2.0.11

If you are flagged with warning to use lower version of SWIG downgrade it with below version. You can also download it from SWIG website or https://sourceforge.net/projects/swig/files.

```
cd swig-2.0.11
./autogen.sh
./configure
make
make check
make install
```

8.5 Pandas

You may also need to download Pandas for your python installation, SPANDAK needs a working Pandas library.

```
pip install pandas
```

8.6 gcc-9

This section is only needed for users using latest gcc versions (Users with Ubuntu 20.04 and above).

While installing few softwares like Sigproc and PSRCAT you'll encounter an error due to gcc. It can be bypassed by using older versions of gcc.

For installing gcc-9 on a latest Ubuntu system, you can use apt manager " `sudo apt install gcc-9` ".

For even earlier versions you may need to compile it manually or use "add repository" option in apt.

After installing gcc-9, you'll need to update the "gcc" priority from existing higher gcc version to gcc-9. It can be done by using command :

" `sudo update-alternatives --install /usr/bin/gcc gcc /usr/bin/gcc-9 1` ".

8.7 Using Python 2 on Ubuntu 22.04 or Anaconda

This section is only needed for users using latest gcc versions (Users with Ubuntu 20.04 and above).

You'll certainly need to update gcc to gcc-9. Additionally, all the packages in Dependencies section can be installed as it is except python related packages. For. e.g "python-scipy". This is because Python2 packages are discontinued from latest apt.

You can install them using pip. If you are using Anaconda, then pip is already given. Just use " `pip install scipy astropy` " and the packages will be installed successfully, If you are using Python2 from Ubuntu, then you need to first get pip (python 2) and then follow that command. https://linuxize.com/post/how-to-install-pip-on-ubuntu-22.04/ This article may help you in installing pip.

Finally you'll need to update "python" priority to Python2. It can be done using command :
"`sudo update-alternatives --install /usr/bin/python python /usr/bin/python2.7 1`".

Anaconda users don't need to do this, just activate your Python 2 environment and you are good to go.

9. SPANDAK (Vishal Gajjar)

You can read more about SPANDAK on Dr. Vishal Gajjar's github and webpage.

```
git clone https://github.com/gajjarv/PulsarSearch.git
```

To use SPANDAK one needs to have all its dependencies mentioned in Section 5 installed successfully.
After cloning the repository perform the below edits for paths.

1. Edit SP_search_BL.py and other SP search files and replace
   "/home/vgajjar/SP_search_wrapper/PulsarSearch/robert_sp/ "
   with your location of PulsarSearch.
   For me it is " /home/USER/pulsar_repo/PulsarSearch/robert_sp "

2. Edit Pulsar_Search_BL.py. On line 555 replace path of the psr_cat.txt with your location of PulsarSearch folder. For me it is
   " /home/USER/pulsar_repo/PulsarSearch "

Finally set the PulsarSearch location in $PATH to access the programs from any folder. If you've followed Environment variable section then it is already set.
You can test the installation using test filterbank.

```
wget https://www.cv.nrao.edu/~sransom/GBT_Lband_PSR.fil

SP_search_BL.py --fil GBT_Lband_PSR.fil --dorfi --boxcar_max 256 --hidm 500

Pulsar_Search_BL.py --i GBT_Lband_PSR.fil
```

You'll see results of the analysis in a new folder named "Mystery_PSR_53010_4848".

References

1. http://ipta.phys.wvu.edu/ipta-2012/workshop/software-ubuntu.html

2. https://www.atnf.csiro.au/people/Lawrence.Toomey/pulsarref/

3. A Manual shared by Dr. Yogesh Maan on installing Pulsar softwares.

4. http://www.pulsarastronomy.net/pulsar/software

5. https://sourceforge.net/p/heimdall-astro/wiki/Install/

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