rtCloud

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Jun 09, 2022

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REALTIME FMRI CLOUD FRAMEWORK

- Github Repo
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The Realtime fMRI Cloud Framework is an open-source software package that makes it easier to build and deploy real-time fMRI experiments. The framework provides a coordination hub between the experimenter's script, a subject feedback script, the scanner data, and experiment control. It streams scanner data (in real-time) to an experimenter's script and forwards the results for use in subject feedback (optionally using tools like PsychoPy, jsPsych, or PsychToolbox). It provides a web-based user interface that allows for starting and stopping runs, changing settings, and viewing output. It can be configured to run in the cloud, on a cluster, or in the control room. Development was initially funded by Intel Labs; the framework is under active development with funding from NIMH to further extend its capabilities, including support for standards such as BIDS and OpenNeuro.org.

For more information on RT-Cloud, see our paper in NeuroImage 2022. If you publish work that utilized RT-Cloud, please include a citation to this paper.

2.1 How it works

There are four general components:

- **Data Server (ScannerDataService)**
  - Watches for new DICOM images written by the MRI scanner.
  - Sends the DICOM images to the projectInterface in the cloud.
  - Listens for requests from the cloud projectInterface to either read or write files (within restricted directories) on the scanner computer.
- **Project and Web Interface (ProjectServer)**
  - Runs in the cloud.
  - Provides a user interface to start/stop and configure a run.
  - Is the communication link between the scannerDataService and the project-specific experiment classification script that runs in the cloud.
- **Project Specific Classification Script**
  - Classification script specific to the fMRI study being done.
  - Is started / stopped by the projectInterface and runs in the cloud.
  - Waits for DICOM files to be retrieved by the scannerDataService, creates a data model, returns classification results via the subjectService or scannerDataService for feedback purposes.

- **Subject Feedback (SubjectService)**
  - Runs on the presentation computer.
  - Listens for classification results sent from the projectServer which were generated by the project-specific classification script.
  - Uses the classification results in combination with a feedback toolkit and script, such as using PsychoPy, JsPsych, or PsychToolbox, to provide feedback to the subject in the MRI scanner.

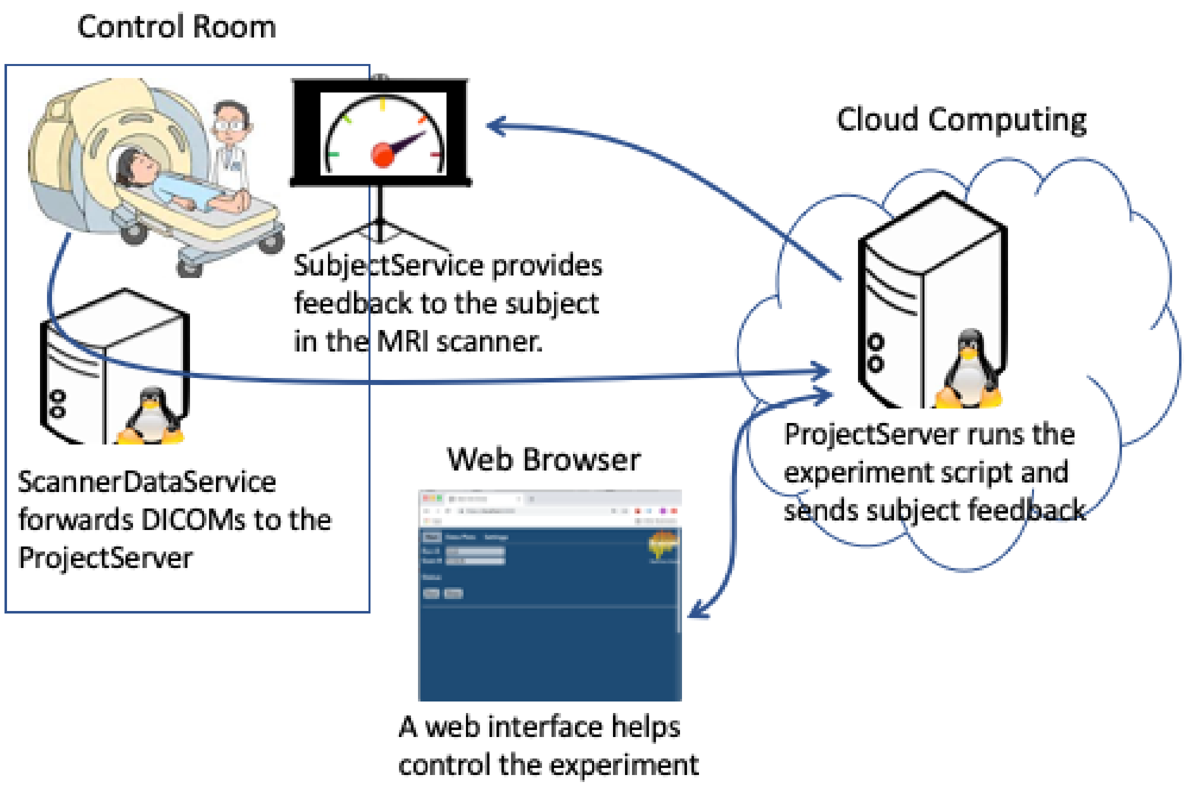


Fig 1: Overview of Components

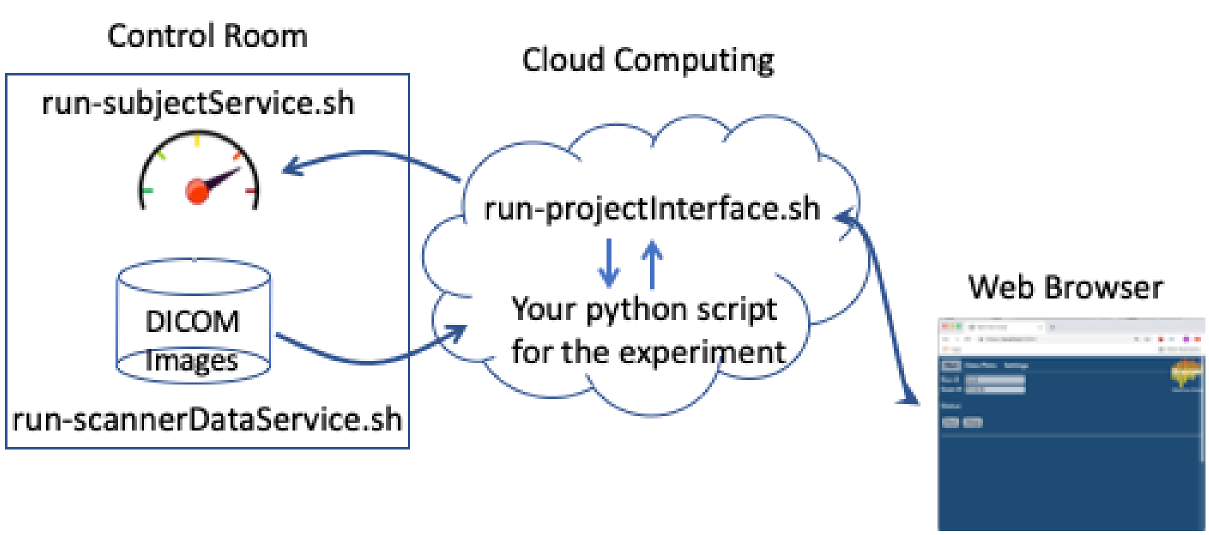


Fig2: Overview of Where Scripts Run

A projectInterface is started on the cloud computer (or it can instead be run on a local or cluster computer). The projectInterface has a web interface which a browser can connect to and allows configuring and starting a run. The web interface is configured so that the browser 'start button' starts the project specific script. Wherever the projectInterface is installed is where your project specific python script will also run. The projectInterface also serves as the intermediary for communication between the the scannerDataService (running in the control room), the project specific script (running in the cloud) and the subjectService for feedback (running on the presentation computer).

A scannerDataService is started on the scanner computer that can watch for files within specified directories. The scannerDataService connects to the projectInterface using a username and password to connect and login.

A subjectService is started on the presentation computer. The subjecService listens for classification results from the project-specific script running in the cloud. These results can then be used by a presentation script to provide feedback to the subject in the MRI scanner. The subjectService connects to the projectInterface using a username and password to connect and login.

2.2 Other Links

- *Wrapping Your Experiment Script with the RealTime Framework*
- *Running a Realtime Experiment*
- *Providing Subject Feedback*
- *Using BIDS Data Format in RT-Cloud*
- *Run Project in a Docker Container*

2.3 Installation

2.3.1 Step 1: Install Mini-Conda and NodeJS

On the cloud computer where processing will take place, do these steps

1. Check if you have mini-conda already installed. In a terminal run conda -V
   - *Mac Specific:* Install Mini-Conda
   - *Linux Specific:* Install Mini-Conda
     - wget https://repo.continuum.io/miniconda/Miniconda3-latest-Linux-x86_64.sh
     - bash Miniconda3-latest-Linux-x86_64.sh -b
2. Check if you have Node.js and NPM installed. In a terminal run node -v and npm -v
   - **Update:** Node.js is now included in the conda environment which will be created in Step 5 below, 'Create the conda environment'
   - *Mac Specific:* Install Node.js
     - Check if Homebrew 'brew' is installed run brew -h
       * Install Homebrew if it is not installed
     - Run brew update
     - Run brew install node

- *Linux Specific* (CentOS): Install Node.js
  - sudo yum install epel-release
  - sudo yum install nodejs

2.3.2 Step 2: Install Realtime ProjectInterface on cloud VM (All OS types)

On the cloud computer where processing will take place, do these steps

1. Pull the source code git clone https://github.com/brainiak/rt-cloud.git
2. cd rt-cloud/
3. Get the local ip address <*local_ip_addr*>
   - *Mac Specific:* Google "what's my ip address"
   - *Linux Specific:* hostname -i
4. Make a private key and an ssl certificate or copy an existing one into the certs directory
   - mkdir certs; openssl genrsa -out certs/rtcloud_private.key 2048
   - bash scripts/make-sslcert.sh -ip *[local_ip_addr]*
5. Create the conda environment
   - conda env create -f environment.yml; conda env update -f environment-synthetic-data.yml
   - conda activate rtcloud
6. Install node module dependencies
   - cd web; npm install; cd ..
7. Create a user:
   - bash scripts/add-user.sh -u [new_username] -p [password]

2.3.3 Step 3: Install ScannerDataService and/or SubjectService on the Console and Presentation Computers (All OS Types)

On the console computer where DICOMs are written, do these steps

1. Repeat Step 1.1 above to install Mini-Conda
2. Clone the rt-cloud code git clone https://github.com/brainiak/rt-cloud.git
3. Copy the ssl certificate created in Step 2.4 above to this computer's rt-cloud/certs directory
   - Copy rt-cloud/certs/rtcloud.crt and rt-cloud/certs/rtcloud_private.key from the cloud computer
   - Copy it into the rt-cloud/certs directory on the scannerDataService computer and subjectService computer

2.4 Testing the Sample Project

For the sample we will run all services (the projectInterface, scannerDataService, and subjectService) on the same computer. Follow the above installation steps; the three service will be run from the same installation directory on the same computer. In a production deployment the projectInterface would typically run in a cloud VM, the scannerDataService would run on the control room console computer, and the subjectService would run on the presentation computer.

Note: The –test option runs in test mode which doesn't use SSL encryption and accepts a default username and password, both are 'test'. **Never run with the –test option in production.**

1. Open a terminal
   - Start the projectInterface
     - conda activate rtcloud
     - bash scripts/run-projectInterface.sh -p sample –dataRemote –subjectRemote –test
2. Open another terminal
   - Start the dataScannerService
     - conda activate rtcloud
     - bash scripts/run-scannerDataService.sh -s localhost:8888 -d $PWD,/tmp –test
3. Open a third terminal to start the subjectService (where feedback is received)
   - Start the subjectService to receive subject feedback on the presentation computer
     - conda activate rtcloud
     - python rtCommon/subjectService.py -s localhost:8888 –test
4. Navigate web browser to URL http://localhost:8888
   - If prompted for username and password enter: username 'test', password 'test'
5. Alternate step 4 - Run the sample project from the command line (it will automatically connect to a local projectServer and receive data from the scannerDataService)
   - conda activate rtcloud
   - python projects/sample/sample.py

2.4.1 Using the Sample Project with synthetic data generated by BrainIAK

1. Alternate to step 1 above
   - Start the projectInterface using the syntheticDataSample project
     - conda activate rtcloud
     - bash scripts/run-projectInterface.sh -p syntheticDataSample –dataRemote –test
2. through 5. same as above.

2.5 Next Steps

1. Run the sample project without the –test options. This will require the following steps. See *Running a Realtime Experiment* for instructions on accomplishing these steps.
   - Add the SSL certificate *rtcloud/certs/rtcloud.crt* that was created in install step 2 above into your web browser.
   - Include the -ip [local_ip_addr] option when starting the projectInterface.
   - Include the -u [username] and -p [password] options when starting the scannerDataService. Use the username and password created in install step 2 above.
   - Navigate web browser to http**s**://localhost:8888 for a SSL connecton
     - i.e. instead of the non-SSL http:// address used above for testing
   - When prompted for login by Web browser use the username and password created in install step 2 above.
2. Install and run the projectInterface on a remote computer. Run the scannerDataService on the computer where the DICOMs are written.
3. Create your own project python script and wrap it with the real-time framework. See *Wrapping Your Experiment Script with the RealTime Framework*

2.6 Troubleshooting

1. Python module not found - make sure you have installed and activate the conda environment: 'conda activate rtcloud'. See installation step 2.5 above.
2. Web page gives a blank blue screen - the web javascript bundle wasn't built, 'cd web; npm install; npm run build'. See installation step 2.6 above.
3. ScannerDataService or subjectService can't connect to the projectInterface.
   - Try specifying the '–test' option to all components (projectInterface, scannerDataService, subjectService). This will disable ssl and allow login with a test user, username: test, password: test. The web page will now be at http://localhost:8888 (*not https://*)
   - Make sure the projectInterface computer's firewall has port 8888 open. Try using an ssh tunnel if in doubt, 'ssh -N -L 8888:localhost:8888 [remote-computer]'
   - Try running the scannerDataService on the same computer as the projectInterface to test the connection.
   - Try using a different port, specify the '–port [new_port]' option when starting the projectInterface and when starting the scannerDataService specify the appropriate port using -s [remote-computer]:[port].
   - Make sure the ssl certificate and private key (rtcloud.crt and rtcloud_private.key) that were created on the projectInterface computer have been copied to the rtcloud/certs directory on the scannerDataService and subjectService computers.
   - Make sure you have created a username and password using the 'scripts/add-user.sh' script.
4. ProjectInterface cannot find your experiment script. Make sure your script's name matches the project directory. Or specify the '–mainScript [script-name]' option when starting the projectInterface. In addition the '–initScript [init-script]' and '–finalizeScript [finalize-script]' options can be used to specify the session initialization and finalization scripts.
5. ProjectInterface or web page indicate 'RemoteServie: DataService not connected'. This means you started the projectInterface using the –dataRemote option but that a scannerDataService has not established a connection

to the projectInterface, so it cannot make remote requests for data. Similarly for 'SubjectService not connected' errors.

6. An error in your script. Try running your script without starting the projectInterface. The clientInterface() method called by your script will create an internal version of the data services if there is no projectInterface started on localhost. If you specify yesToPrompts=True when instantiating the clientInterface (ClientInterface(yesToPrompts=True)) it will automatically use local services if there is no projectInterface running.
7. A DICOM error is reported such as, *"ValueError: The length of the pixel data in the dataset (287580 bytes) doesn't match the expected length (294912 bytes). The dataset may be corrupted or there may be an issue with the pixel data handler"*. This usually indicates that the DICOM file was read by the FileWatcher before the file was completely written. To handle this, adjust the 'minFileSize' parameter that is passed to dataInterface.initWatch() or dataInterface.initScannerStream(), see the projects/sample/sample.py for an example. The minFileSize indicates a lower bound file size (in bytes) below which the FileWatcher will continue waiting before reading a file. Set the minFileSize to slightly below the smallest DICOM file size expected.

2.7 Running the Automated Test Suite

1. Follow the installation instructions detailed above
2. Activate the conda environment
    - conda activate rtcloud
3. Additionally, install bids-validator
    - npm install -g bids-validator
4. Run the test suite
    - python -m pytest -s -v tests/

2.8 Further Reading

- *Run Project in a Docker Container*
- Details - coming soon

CHAPTER

THREE

RUNNING A REALTIME EXPERIMENT

3.1 Running the ProjectInterface

The projectInterface is typically run on a VM in the cloud (i.e. a 'remote' computer) which does not have direct access to the DICOM images. The advantage of a cloud VM is that any laptop browser can connect to it and no additional hardware or software installation is needed on the control room computer. However the projectInterface can also be run on a 'local' computer, meaning on the same computer in the control room where the DICOM images are written.

3.1.1 Running ProjectInterface in the Cloud

1) Start the projectInterface From the cloud VM computer run the following command. See Definitions Section for description of the parameters.

```
cd rtcloud/
conda activate rtcloud
bash scripts/run-projectInterface.sh -p [your_project_name] -c [config_file] -ip [local_
↪ip_addr] --dataRemote --subjectRemote
```

Example:

```
bash scripts/run-projectInterface.sh -p sample -c projects/sample/conf/sample.toml -ip␣
↪125.130.21.34 --dataRemote --subjectRemote
```

The -p option is used to locate your project in the */rt-cloud/projects/* directory, the name specified should match your project directory name.

The -c option points to your project configuration file in toml format.

The -ip option is to update the ssl certificate with the ip address where the projectInterface runs. Use 'hostname -i' or Google 'what's my ip address' to get the ip address of that computer.

2) Start the scannerDataService The scannerDataService is started on the control room computer where the DICOM images are written by the scanner. It can forward those images to the projectInterface when requested by your project code. The *[username]* and *[password]* are the login credentials to the projectInterface because the scannerDataService must connect to the projectInterface to be able to serve files to it.

```
bash scripts/run-scannerDataService.sh -s [projectInterface_addr:port] -d [allowed_dirs]␣
↪-f [allowed_file_extensions] -u [username] -p [password]
```

Example:

```
bash scripts/run-scannerDataService.sh -s 125.130.21.34:8888 -d /tmp,/data/img -f .dcm,.
↪txt
```

3) Start the SubjectService The subjectService is started on the presentation computer where PsychoPy or similar software will run to provide feedback to the subject in the MRI scanner. The *[username]* and *[password]* are the login credentials to the projectInterface because the subjectService must connect to the projectInterface to be able to receive classification results.

```
bash scripts/run-subjectService.sh -s [projectInterface_addr:port] -u [username] -p␣
↪[password]
```

Example (run from the rt-cloud directory):

```
bash scripts/run-subjectService.sh -s 125.130.21.34:8888 -u user1 -p passwd1
```

3.1.2 Running ProjectInterface Locally

The projectInterface can also be run on the control room computer where the DICOM images are written. This is called running it 'locally'. When run locally the fileServer (scannerDataService) is not needed because the projectInterface can directly read the DICOM images from disk.

1) Start the projectInterface: same command as above but without the –dataRemote or –subjectRemote options

```
bash scripts/run-projectInterface.sh -p [your_project_name] -c [config_file] -ip [local_
↪ip_addr]
```

Example:

```
bash scripts/run-projectInterface.sh -p sample -c projects/sample/conf/sample.toml -ip␣
↪125.130.21.34
```

3.2 Connecting with the Browser

3.2.1 SSL Certificate Installation

The connection between your web browser and the projectInterface is encrypted using SSL for security. In order for your browser to trust the connection to the projectInterface, the SSL certificate created during the projectInterface installation process must be added to a list of trusted certificates on your browser computer.

Copy the ssl certificate **rtcloud/certs/rtcloud.crt** to your computer running the web browser.

3.2.1.1 Install the SSL Certificate in your Web Browser

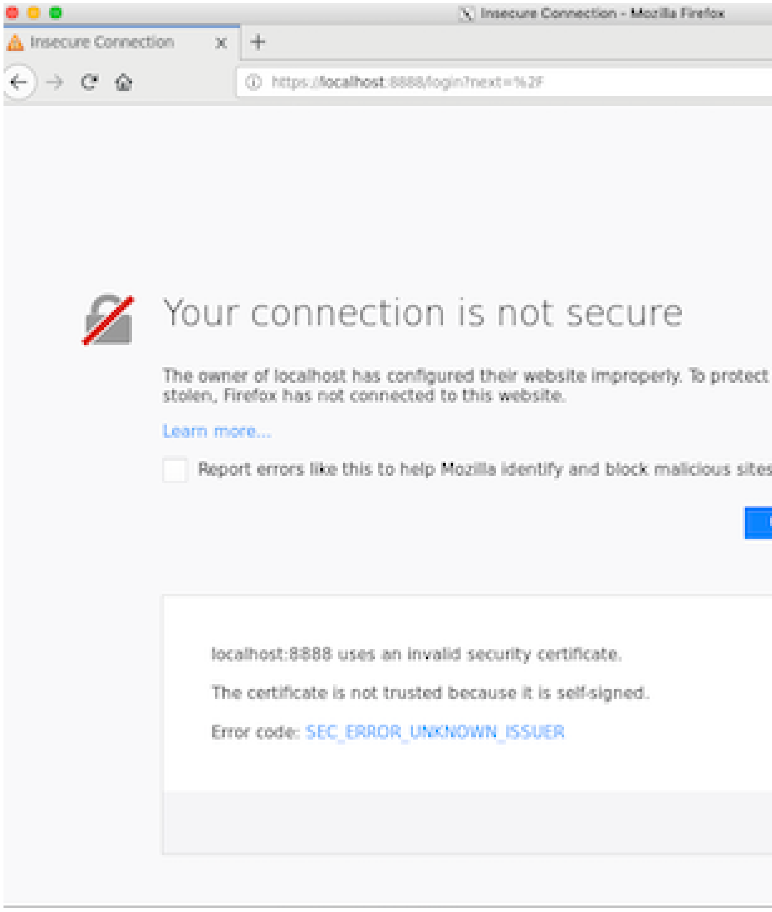
On Mac:

1. Open application 'Keychain Access'.
2. Click on 'Certificates' in bottom left pane
3. Select File->Import Items… and select the ssl certificate downloaded to your computer
4. In 'Certificates' pane, double-click the 'rtcloud.princeton.edu' certificate

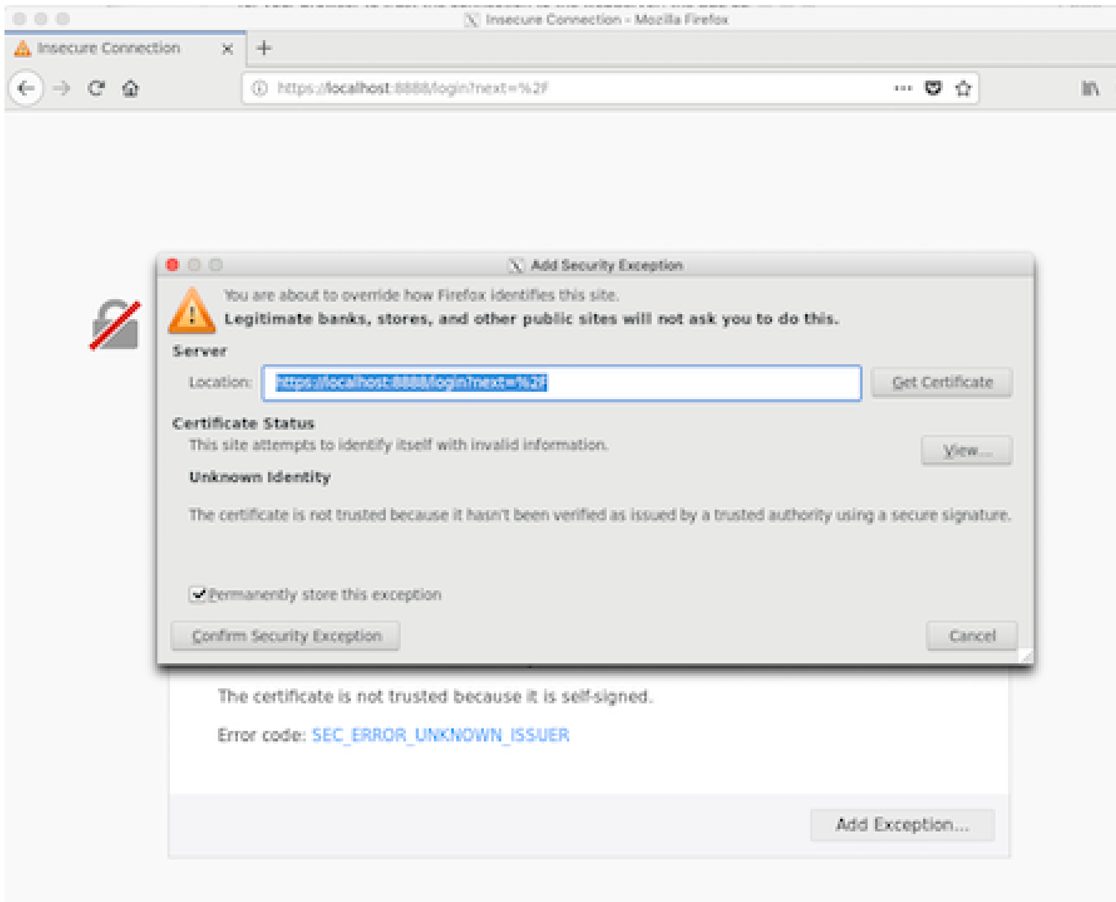
5. Select the 'Trust' drop-down item.
6. In 'When using the certificate' selector choose 'Always Trust'

On Linux:

1. Navigate to the projectInterface web URL, e.g. https://localhost:8888



- You will see a security warning about untrusted certificate
- Click 'Add Exception'



- You will see a dialog box
- Click 'Confirm Security Exception'

3.2.2 Open Web Page in Browser

1. Open a browser and navigate to **https://<projectInterface_addr>:8888**
2. On the login screen enter the **[username]** and **[password]** that were created during installation by the adduser.sh script

3.2.3 Notes on Security

There are several security mechanisms

- **Encryption** - Using SSL connections means all data is encrypted in transit.
- **Password** - A username and password mean that only authorized users can connect to the projectInterface.
- **Restricted directories** - The fileserver restricts which directories it will return files from.
- **Restricted file types** - The fileserver restricts which file types (denoted by the file extension, e.g. .dcm) it will return.
- **Direction of connection** - The fileserver doesn't allow connections to it. The fileserver always initiates the connection going to the projectInterface.

3.3 Using VNC Server to view an application's display on the server

Sometimes it is necessary to see the GUI (graphical window) output of a program running on the projectServer computer. For example, during session initialization a researcher may want to run FSLview to see if the image registration looks correct. This can be done by running a VNC Server on the computer where the projectServer is running. The VNC Server starts a second virtual display (:1) and any application can then render to that display. The web interface has a tab called 'VNC Viewer' which can view and interact with the content on that display. Note: the VNC Server uses a program called websockify which can wrap any TCP/IP program so that it can be accessed from a websocket client, websockify wraps VNC Server for this purpose.

3.3.1 Install VNC Server on the projectServer Computer

1. Install the websockify conda environment:

```
conda env create -f websockify.yml
```

2. Install VNC on the server:

```
sudo yum -y install tigervnc-server
sudo yum -y install xclock
sudo yum -y install xdotool

cat <<EOT >> ~/.vnc/xstartup
unset SESSION_MANAGER
unset DBUS_SESSION_BUS_ADDRESS
#exec /etc/X11/xinit/xinitrc
xsetroot -solid grey -cursor_name left_ptr
xeyes
EOT
```

3. Start the VNC Server running with websockify to serve connection requests:

```
bash scripts/run-vnc.sh
```

4. Applications started on the projectServer, such as from the session initialization script, can redirect their output to the VNC display by prepending "DISPLAY=:1" to the command. For example: DISPLAY=:1 xclock

5. The VNC display can be viewed from the VNC Viewer tab of the web interface. Click 'reconnect' if needed to re-initialize the VNC connection.

3.4 Definitions

- **[allowed_dirs]** - This allows restricting which directories the fileServer is allowed to return files from. Specify as a comma separated list with no spaces, e.g. '-d /tmp,/data,/home/username'
- **[allowed_file_extensions]** - This allows restricting which file types the fileServer is allowed to return. Specify as a comma separated list with no spaces, e.g. '-f .dcm,.txt,.mat'
- **[config_file]** - the location of project specific configurations in a toml file format. This will typically be located in a directory within the project such as *rtcloud/projects/your_project/conf/*. E.g. the sample project config file is *rtcloud/projects/sample/conf/sample.toml*
- **[local_ip_addr]** - network address of the computer where a command is issued

  - Get the local ip address
    * Mac: Google "what's my ip address"
    * Linux: hostname -i
- **[username] [password]** - The username and password to login to the projectInterface. This was created with the adduser.sh script during installation of the projectInterface.
- **[projectInterface_addr:port]** - The network address and port number that the projectInterface is listening on. The default port is 8888. E.g. '-s 125.130.21.34:8888'
- **[your_project_name]** - The name of the subdirectory under the *rtcloud/projects/* directory which contains your project specific code. Your script should use the same name as the directory, i.e. sample.py, so that the projectInterface can find it.
- **[run]** - An fMRI scanner acquisition block of images. For example running the scanner to collect a block of 200 scans with a TR image repetition time of 2 seconds; this run will take 400 seconds and generate 200 DICOM images.
- **[scan]** - The file sequence number corresponding to a run. For example, in the image name '001_000014_000005.dcm', the scan number is 14 and the image volume number (TR id) is 5.

CHAPTER

FOUR

MAKING YOUR PROJECT CLOUD ENABLED

Make a new directory under rt-cloud/projects for your project. Use the sample project in *rt-cloud/projects/sample* as a template for making your python script cloud enabled. The sample.py script corresponds to the script you will make for your experiment.

4.1 Project Code

You'll need to copy several blocks of code to your project to get it cloud enabled. These are:

4.1.1 Initialization code

Accept at least the following command line parameters in your project python file:

```
argParser = argparse.ArgumentParser()
argParser.add_argument('--config', '-c', default=defaultConfig, type=str,
                       help='experiment config file (.json or .toml)')
argParser.add_argument('--runs', '-r', default='', type=str,
                       help='Comma separated list of run numbers')
argParser.add_argument('--scans', '-s', default='', type=str,
                       help='Comma separated list of scan number')
args = argParser.parse_args()
```

Create an clientInterface instance for communicating with the projectInterface. The clientInterface automatically connects to a localhost projectInterface when created.

```
clientInterface = ClientInterface()
```

The clientInterface provides several interfaces for retrieving data, giving subject feedback, and updating the user's webpage.

```
dataInterface = clientInterfaces.dataInterface
subjInterface = clientInterfaces.subjInterface
webInterface  = clientInterfaces.webInterface
```

Note: The clientInterfaces connect to remote services with the following mapping:

```
dataInterface --> scannerDataService
subjInterface --> subjectService
webInterface  --> user web browser
```

4.1.2 Retrieving DICOM Images from the Scanner Computer

Within your python script, use the `dataInterface` object to request remote files. For example, to retrieve DICOM images as they are created, init a watch on the appropriate directory and then watch for them.

```
dataInterface.initWatch('/tmp/dicoms', 'samp*.dcm', minFileSize)
rawData = dataInterface.watchFile('/tmp/samp3.dcm')
```

Or use the readRetryDicom helper function which will retry several times across timeouts to retrieve the DICOM image data:

```
dataInterface.initWatch('/tmp/dicoms', 'samp*.dcm', minFileSize)
dicomData = readRetryDicomFromDataInterface(dataInterface, 'samp3.dcm', timeout=10)
```

Or use the streaming interface to receive image data:

```
streamId = dataInterface.initScannerStream('/tmp/dicoms', 'samp*.dcm', minFileSize)
dicomData = dataInterface.getImageData(streamId, int(this_TR), timeout=10)
```

Set the minFileSize parameter to the minimum size expected for DICOM files (in bytes). This can be determined by listing the sizes of a set of previously collected DICOM files and selecting slightly less than the smallest as the minimumFileSize. The FileWatcher will not return a file until its minimum size has been reached, this helps ensure that a file is completely written before being made available. However, if this parameter is set too high (higher than the file size) the file will never be returned.

4.1.3 Send Classification Results for Subject Feedback

Send classification results to the presentation computer using the subjectInterface setResult() command:

```
subjInterface.setResult(runNum, int(TR_id), float(classification_result))
```

Or send classification results to a file on the scanner computer (where scannerDataService is running) which can be read in by a script (e.g. using a toolkit like PsychToolbox) for subject feedback.

```
dataInterface.putFile(fullpath_filename_to_save, text_to_save)
```

4.1.4 Update the User's Webpage Display

Send data values to be graphed in the projectInterface web page

```
webInterface.plotDataPoint(runNum, int(TR_id), float(classification_result))
```

4.1.5 Read Files from the Console Computer (such as configuration files)

Read files from the console computer using getFile

```
data = dataInterface.getFile(fullpath_filename)
```

Or read the newest file matching a file pattern such as 'samp*.dcm'

```
data = dataInterface.getNewestFile(fullpath_filepattern)
```

4.1.6 Load Project Configurations

RT-Cloud experiments use a TOML file for configuration settings. You can define your own configuration variables just by adding them to the TOML configuration file. Your configuration variables will automatically appear in the web interface 'settings' tab and you can adjust the values from that page.

Use the loadConfigFile function from your experiment script to load your configurations into a structured object

```
import rtCommon.utils as utils
cfg = utils.loadConfigFile(args.config)
```

Access configurations within your experiment script using the config structure

```
print(cfg.subjectName, cfg.run)
```

The following fields must be present in the config toml file for the projectInterface to work:

- runNum = [1] # an array with one or more run numbers e.g. [1, 2, 3]
- scanNum = [11] # an array with one or more scan numbers e.g. [11, 13, 15]
- subjectName = 'subject01'

Optional parameters used for plotting:

- title = 'Project Title'
- plotTitle = 'Plot Title'
- plotXLabel = 'Sample #'
- plotYLabel = 'Value'
- plotXRangeLow = 0
- plotXRangeHigh = 20
- plotYRangeLow = -1
- plotYRangeHigh = 1

Additionally, create any of your own unique parameters that you may need for your experiment.

4.1.7 Timeout Settings

RT-Cloud uses RPC (Remote Procedure Calls) to send command requests from the researcher's experiment script to the dataInterface, subjectInterface and webInterface. There are two RPC hops to handle a request. The first uses RPyC (a native Python RPC library) to make a call from the script to the projectServer. The second is using a WebSocket RPC implemented in rtCommon/remoteable.py and invoked from rtCommon/projectServerRPC.py to make the call from the projectServer to the remote service (such as DataService). For each hop a global timeout can be set, and a per-call timeout can also be set.

4.1.7.1 Setting Global Timeouts:

- The RPyC global timeout can be set when the ClientInterface is created in the experiment script, as demonstrated in the sample.py project. Simply include the rpyc_timeout= parameter (e.g. ClientInterface(rpyc_timeout=10) for a 10 second timeout). The default is 120 seconds.
- The Websocket RPC global timeout can be set using the setRPCTimeout() of interface objects (i.e. remoteable objects). For example to increase the timeout of the dataInterface in the experiment script, call dataInterface.setRPCTimeout(10) for a 10 second timeout. The default websocket timeout is 60 seconds.

4.1.7.2 Setting Per-Call Timeouts:

- Per-call timeouts for both RPyC and Websocket RPC are set together using the same parameter. To set a larger timeout for a specific call, include a "rpc_timeout" kwarg in that calls parameters. For example, use dataInterface.getFile("bigfile.bin", rpc_timeout=60) to set a 60 second timeout for a large file transfer. Note that before setting an RCP timeout you should check that the interface is connected to the ProjectServer, because sometimes interfaces will run locally. To check that, use an interface's .isUsingProjectServer() command, such as dataInterface.isUsingProjectServer(), see the openNeuroClient project for an example of this usage.

4.2 Some Alternate Configurations For Your Experiment

4.2.1 Running everything on the same computer

Start the projectInterface without the –dataRemote or –subjectRemote options. No need to start any other services, local versions of them will be created internally by the projectInterface.

```
bash scripts/run-projectInterface.sh -p [your_project_name]
```

4.2.2 Running the subjectService remotely, but read DICOM data from the disk of the projectInterface computer

Start the projectInterface only specifying –subjectRemote. Then start a subjectService on a different computer that will connect to the projectInterface. The scannerDataService will automatically be created internally by the projectInterface to read data from the projectInterface computer.

```
bash scripts/run-projectInterface.sh -p [your_project_name] --subjectRemote
```

4.2.3 Reading both remote and local data

Start the projectInterface with the –dataRemote option and connect to it with a scannerDataService from another computer. In addition create another instance of dataInterface() within your script specifying dataRemote=False. This second dataInterface can watch for DICOM files created locally and the remote dataInterface can get/put files to the remote scannerDataInterface (for example to write a text file with the classification results for use by PsychToolbox).

```
dataInterface2 = DataInterface(dataRemote=False, allowedDirs=['*'], allowedFileTypes=['*
→'])
```

CHAPTER

FIVE

PROVIDING FEEDBACK TO SUBJECTS

Ideally we would like to provide feedback to the subject in the MRI scanner via a web interface. This would allow the researcher to open a web browser and move the browser onto a monitor visible by the subject in the scanner. One convenient toolbox for doing this is jsPsych. We have integrated jsPsych into our project and provide a demo using the DecNef style colored circle feedback.

5.1 Using jsPsych

The source code components of jsPsych live in the `web/` directory. File `web/jsPsychFeedback.html` is the main file that will be edited to adjust the type of feedback displayed. The creating a new `draw` method different types of feedback can be created.

5.1.1 Running the Demo

1. The projectServer must be started with –remoteSubject options enabled to allow the feedback webpage to connect and receive results from the projectServer.
    - conda activate rtcloud
    - bash ./scripts/run-projectInterface.sh –test -p sample –subjectRemote
2. Connect a web browser to the main page
    - http://localhost:8888/
    - Enter 'test' for both the usnername and password since we are running it in unsecure test mode.
3. Connect a web browser to the jsPsych feedback page
    - http://localhost:8888/jspsych
4. Click the 'Run' button on the main page and view the subject feedback shown on the jsPsych page

CHAPTER

SIX

USING THE BIDS DATA STANDARD WITH RT-CLOUD

Note: Some of this documentation is taken from Polcyn, S. (2021) "Efficient Data Structures for Integrating the Brain Imaging Data Structure with RT-Cloud, a Real-Time fMRI Cloud Platform" [Unpublished senior thesis].

6.1 BIDS Introduction

BIDS is the leading data standard for neuroscience data and is supported by a wide variety of data formatting and analysis tools. It is the standard used by OpenNeuro which is a large and growing repository of neuroscience datasets. In addition there are a large set of BIDS Apps, which are container-based applications with a standardized interface that work on BIDS-formatted data. The BIDS Validator is an automated and comprehensive validation tool that analyzes datasets and identifies BIDS compliance issues.

6.1.1 The BIDS Archive

The BIDS standard defines the on-disk layout and format of datasets to form a BIDS archive. A BIDS archive is a collection of brain activity image and metadata files for one study, which may comprise multiple subjects across multiple days. While an in-depth understanding of the BIDS standard can be obtained from the full standard, viewable online at https://bids-specification.readthedocs.io/en/stable/, a few key details are as follows:

1. **Brain imaging data is stored in the Neuroimaging Informatics Technology Initative (NIfTI) format.** NIfTI is a binary file format that starts with a header holding basic information about the brain data contained in the file. The header is followed by the raw brain data. A NIfTI volume's data typically has 4 dimensions, *x, y, z* and *t (time)*, so a NIfTI file can be thought of as containing a sequence of *t*, 3-D images, each of which has dimensions `x * y * z`.
2. **Metadata is stored in files separate from the image data.** Unlike the DICOM image format, the NIfTI image format doesn't store much metadata about the image it contains. Accordingly, in the BIDS data format, the majority of the metadata about the image and the conditions under which it was collected is stored in separate files, typically in the JavaScript Object Notation (JSON) or Tab-Separated Value (TSV) format.
3. **Files are named using BIDS entities.** The name of a file in a BIDS archive follows a standard format, and it is composed of a set of 'entities' (like 'sub' or 'run', corresponding to 'subject' and 'run', respectively) that signify what the data in the file corresponds to. For example, the filename "sub-01_task-language_run-1_bold.nii" has 4 BIDS entities, separated by underscores ('_'). The 4 entities and their corresponding values are:
    1. 'sub': 01 (this file has data for the subject with ID 01)
    2. 'run': 1 (this file has data from the 1st run)
    3. 'task': language (this file has data from the 'language' task)
    4. 'bold': No value (The presence of the entity is enough to state the file holds fMRI brain-oxygen-level-dependent (BOLD) data)

In summary, a BIDS archive is a collection of image and metadata files, all named using BIDS entities that correspond to the conditions under which the data or metadata was collected.

6.1.2 BIDS Apps

BIDS Apps are containerized applications that operate on BIDS datasets and provide a consistent command-line interface to users. Since each app operates on a BIDS archive, a full analysis pipeline can potentially be created from independent BIDS App containers, so components can be easily added, removed, or modified as needs evolve over time.

6.2 Why Use BIDS with RT-Cloud

6.2.1 BIDS Apps

Using BIDS with RT-Cloud connects you to the BIDS Apps ecosystem, so you can integrate existing and future BIDS Apps with your real-time fMRI analysis pipeline, minimizing time spent on setting up computational infrastructure.

6.2.2 Benefits of BIDS Data Standardization

Storing data in a standardized format brings a host of benefits, the following of which were adapted from here.

One major benefit is you and all lab members or clinical team members, once having learned the standard, know immediately how to navigate both new and old datasets. Without a standardized format, different team members may format their data in different ways, forcing you to waste time learning a myriad of data formats and creating significant problems when a team member leaves the organization and can no longer explain to new or existing team members how their dataset format works. Additionally, external collaborators at other institutions can easily work on your dataset if everyone uses the same standard.

Another major benefit is future software packages are likely to grow around this standard. Thus, you can use any of a wide variety of software packages with your new and existing BIDS datasets that conform to the standard and not spend time learning additional software-specific formats or be locked-in to a particular software package.

Finally, if you are required to publish your datasets as a condition of manuscript publication, having data in a standardized format from the beginning enables a seamless upload and review process.

6.3 Adapting BIDS for use in Real-Time fMRI Experiments

Real-time fMRI experiments involve processing image data as it arrives from the scanner and providing immediate subject feedback. In essence, rt-fMRI is a streaming model, whereas BIDS is a data-at-rest standard. To adopt BIDS for rt-fMRI we introduce a new idea, the BIDS Incremental.

A BIDS Incremental packages one brain volume into its own BIDS archive. Thus, we can use this to send a stream of very small BIDS archives (i.e., BIDS Incrementals) for processing. This allows the processing to be done by any application that can ingest BIDS data, such as BIDS-Apps.

6.4 How to Incorporate BIDS into your RT-Cloud project

There are three primary classes to use to leverage BIDS in your RT-Cloud project: BIDS Incremental, BIDS Run, and BIDS Archive.

1) BIDS Incremental is a single-image data structure, encapsulating a single-volume BIDS Archive.
2) BIDS Run is a data structure that efficiently stores a full run's worth of BIDS Incrementals in-memory and in a deduplicated fashion. It supports appending BIDS Incrementals to a scanning run and retrieving BIDS Incrementals that have already been added.
3) BIDS Archive is a data structure that provides an API for interacting with on-disk BIDS archives and enables efficient movement between the BIDS Run streaming data structure and the on-disk BIDS archive.

Below is a sample of how your project can receive real-time scanner data in BIDS-incremental format. This assumes you are running the scannerDataService in the control room. This example communicates with the scannerDataService via the clientInterface.bidsInterface. A data stream is initialized, giving the scanner directory that the DICOMs will arrive in and the DICOM filename pattern to watch for.

```
from rtCommon.clientInterface import ClientInterface
# connect to the remote data service (via projectServer on localhost)
clientInterfaces = ClientInterface()
bidsInterface = clientInterfaces.bidsInterface
# specify the BIDS entities for the run being done
entities = {'subject': cfg.subjectName,
            'run': cfg.runNum[0],
            'suffix': 'bold',
            'datatype': 'func',
           }
# initialize the stream which will watch for DICOMs created at the scanner
#  and then convert them to BIDS-incrementals and stream them to this script.
streamId = bidsInterface.initDicomBidsStream(cfg.dicomDir,
                                             cfg.dicomScanNamePattern,
                                             cfg.minExpectedDicomSize,
                                             **entities)
# loop over the expected number of DICOMs per run
for idx in range(scansPerRun):
    bidsIncremental = bidsInterface.getIncremental(streamId, idx)
    imageData = bidsIncremental.imageData
    avg_niftiData = numpy.mean(imageData)
    if cfg.writeBidsArchive is True:
        # See openNeuroClient project under 'projects' directory for more
        #  information on accumulating a BIDS archive from a stream of incrementals.
        newRun.appendIncremental(bidsIncremental)
```

Below is a simple example that shows the interactions between the various classes.

```
archive = BidsArchive('/tmp/bidsDataset')
print('Subjects:', archive.getSubjects(), 'Runs:', archive.getRuns())

# Query the run using BIDS Entities (see the tutorial for a deeper introduction)
run = archive.getBidsRun(subject='01', run=1, datatype='func')
newRun = BidsRun()
meanActivationValues = []
```

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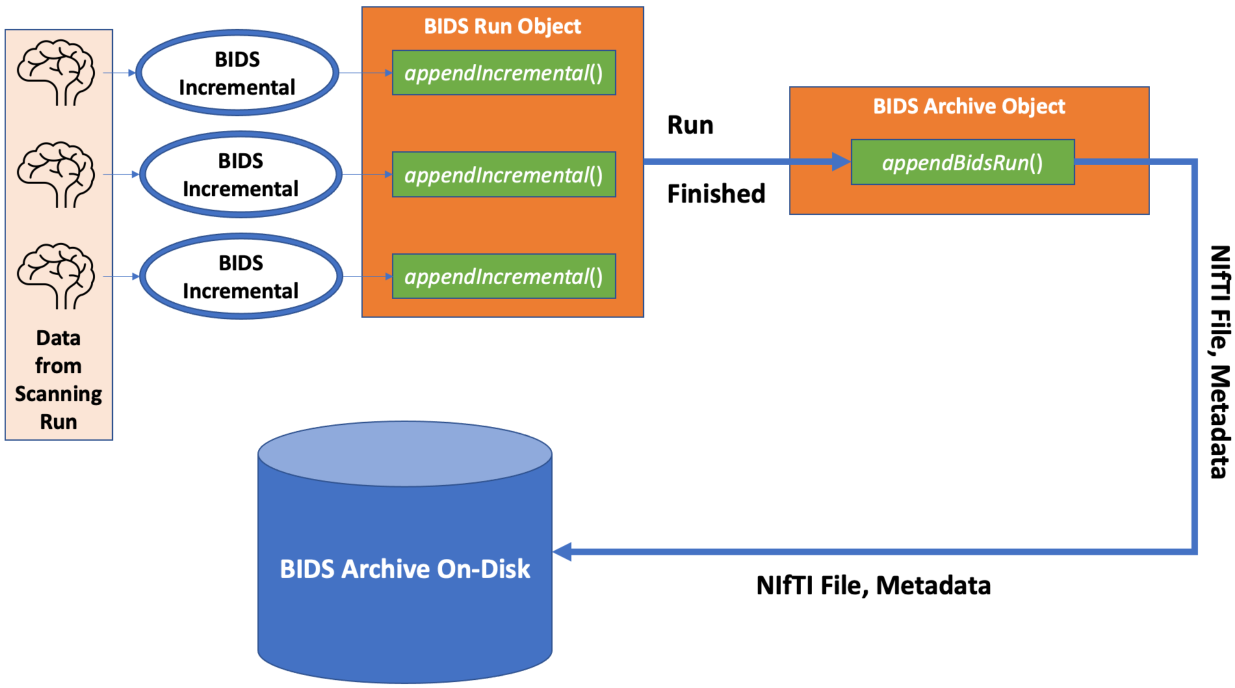
```
for i in range(run.numIncrementals()):
    incremental = run.getIncremental(i)
    meanActivationValues.append(np.mean(incremental.imageData))
    newRun.appendIncremental(incremental)

newArchive = BidsArchive('/tmp/newBidsDataset')
newArchive.appendBidsRun(newRun)
```

An overview of how these classes all fit together for sending data from the MRI scanner to a BIDS Archive is shown here:



Retrieving BIDS data from an archive is simply the reverse of that diagram.

For a more in-depth introduction to the various classes and how to use them, check out the bids_tutorial Jupyter notebook tutorials/bids_tutorial.ipynb.

6.5 Replaying Data from OpenNeuro

One goal of this project is to facilitate collaboration and sharing of code and data. To this end we introduce an OpenNeuro module which can access and stream data from the OpenNeuro.org data repository. In essence this is a 'NetFlix' type service for fMRI datasets. Researchers can replay datasets through their processing pipelines to try new models, reproduce results or test and debug experiments.

An example of streaming OpenNeuro data can be seen in the projects/openNeuroClient sample project. The key snippets of code are shown below.

```
# OpenNeuro accession number for a dataset
dsAccession = 'ds002338'
# The subject and run number to replay
entities = {'subject': 'xp201', 'run': 1}
# Initialize the data stream
```

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```
streamId = bidsInterface.initOpenNeuroStream(dsAccession, **entities)
numVols = bidsInterface.getNumVolumes(streamId)
# Retrieve and process each volume as a BIDS-Incremental
for idx in range(numVols):
    bidsIncremental = bidsInterface.getIncremental(streamId, idx)
    imageData = bidsIncremental.imageData
```

CHAPTER

SEVEN

RUN PROJECT IN A DOCKER CONTAINER

7.1 Allocate a VM in the cloud

If you will run the project on the cloud, the following instructions will help deploy a cloud VM. If you will run the project on local resources skip to the 'Install Docker' section.

- Microsoft Azure instructions: https://docs.microsoft.com/en-us/azure/virtual-machines/linux/quick-create-portal
- Amazon AWS instructions: https://aws.amazon.com/getting-started/tutorials/launch-a-virtual-machine/

7.1.1 Some notes for Azure VM:

- Choose CentOS 7.5 (which the following instructions are based on)
- Create a resource group 'rtcloud' to make it easier to track later
- Choose VM instance type F4s_v2, F8s_v2, or F16s_v2 (depending on number of cores desired)
- Choose premium SSD disk, no need for an extra data disk, but we will extend the main disk to 60 GB after VM creation.
- NIC network security group - choose 'Advanced' to create a network security group. This will allow you later to configure port 8888 as allowed for traffic.
- Choose Auto-shutdown and set a time during the night (in case you forget to power down)

7.2 Install Docker

Install Docker Engine

```
sudo yum install -y yum-utils device-mapper-persistent-data lvm2
sudo yum-config-manager -y --add-repo https://download.docker.com/linux/centos/docker-ce.
↪repo
sudo yum install -y docker-ce docker-ce-cli containerd.io docker-compose
```

Add your username to the docker group (to avoid using sudo for docker commands)

```
sudo usermod -aG docker <username>
newgrp docker
```

Config Docker to start at boot time

```
sudo systemctl enable docker
sudo systemctl start docker
```

test docker

```
docker run hello-world
```

7.3 Install rtcloud for Docker

Pull rtcloud image

```
docker pull brainiak/rtcloud:latest
```

Add the rtgroup Add a new group with GID 5454 to you local system which matches the user and group ID used in the rtcloud Docker container. Add your username to be a member of the rtgroup.

```
sudo groupadd -g 5454 rtgroup
sudo usermod -a -G rtgroup <your-username>
sudo chgrp -R rtgroup <projects-dir>
```

Create the rtcloud ssl certificate This will create a self-signed SSL certificate called **rtcloud.crt** to allow encrypted communication with the projectInterface. You will need to install the rtcloud.crt certificate in your browser for trusted communication. The certificate will be created in location: /var/lib/docker/volumes/certs/_data/rtcloud.crt

```
IP=`curl https://ifconfig.co/`
docker run -it --rm -v certs:/rt-cloud/certs brainiak/rtcloud:latest scripts/make-
↪sslcert.sh -ip $IP
```

Add a user for web interface The web connection to the projectInterface requires a user/password to authenticate. You can create a username and password with this command.

```
docker run -it --rm -v certs:/rt-cloud/certs brainiak/rtcloud:latest scripts/add-user.sh␣
↪-u <username>
```

7.4 Run rtcloud projectInterface

The above installation only needs to be run once, then the projectInterface can be started whenever needed with these commands.

```
IP=`curl https://ifconfig.co/`
PROJ_DIR=<full_path_to_project_dir>
PROJ_NAME=<name>

docker run -it --rm -v certs:/rt-cloud/certs -v $PROJ_DIR:/rt-cloud/projects/$PROJ_NAME -
↪p 8888:8888  brainiak/rtcloud:latest scripts/run-projectInterface.sh -p $PROJ_NAME -c␣
↪projects/$PROJ_NAME/config.toml -ip $IP
```

7.5 Alternate simpler calls using the run-docker.sh script

The rt-cloud githup repo has a run-docker.sh script that encapsulates the docker specific call parameters in the above calls. This can make it simpler to call the functions you want within the docker image. The following shows the previous commands using the run-docker.sh helper script. Set the $PROJ_DIR env variable before calling run-docker.sh so it can map the project directory into the docker container.

```
export $PROJ_DIR=[path-to-your-local-project]
scripts/run-docker.sh scripts/make-sslcert.sh -ip $IP
scripts/run-docker.sh scripts/add-user.sh -u <username>
scripts/run-docker.sh scripts/run-projectInterface.sh -p sample -c projects/sample/conf/
↪sample.toml -ip $IP
```

Or use the –projDir parameter to specify the project directory to map.

```
scripts/run-docker.sh --projDir [path-to-project] scripts/run-projectInterface.sh -p␣
↪sample -c projects/sample/conf/sample.toml -ip $IP
```

7.6 Alternate methods using docker-compose

Docker compose can be used to start a container running with all the appropriate directories and ports mapped, making it easier to issue calls (i.e. run commands) in a continuously running container.

The docker compose file is located at: `rt-cloud/docker/docker-compose.yml`. Edit the docker-compose.yml file and replace `/tmp/myproject` with the path to your project, and update the internal container mount point by replacing 'myproject' in `/rt-cloud/projects/myproject` with your project directory name.

Then start the docker compose container running `docker-compose up`.

```
docker-compose -f docker/docker-compose.yml up &
```

Stop the docker compose container by running `docker-compose down`

```
docker-compose -f docker/docker-compose.yml down
```

The running container will be named `rtserver`. You can then issue commands to the running container such as:

```
docker exec -it rtserver ls /rt-cloud/projects

docker exec -it rtserver scripts/run-projectInterface.sh -p myproject -c /rt-cloud/
↪projects/myproject/config.toml --test
```

This makes it easier to run commands without specifying volumes and ports to map each time, and is more efficient as it uses a running container rather than starting a new container for each command.

7.7 Docker Image with ANTs, FSL and C3D (brainiak/rtcloudxl)

Thers is a version of the rtcloud docker image that also has ANTs, FSL and C3D installed in the image along with the RT-Cloud framework. It is available as brainiak/rtcloudxl:[release-tag], such as brainiak/rtcloudxl:1.3. This container is significantly larger (about 30 GB uncompressed) than the basic rtcloud image, and so is not listed as the default release of the image.

7.8 Building Docker Images

The dockerfiles needed to build the images are in the rt-cloud/docker directory. The commands to build the images are as follows:

```
docker build -t brainiak/rtcloud:latest -f docker/Dockerfile.rtcloud .
docker build -t brainiak/rtcloudxl:latest -f docker/Dockerfile.rtcloudXL .
```

And to re-tag them, such as for a release:

```
docker tag brainiak/rtcloud:latest brainiak/rtcloud:1.3
```

CHAPTER

EIGHT

API REFERENCE

This page contains auto-generated API reference documentation[1].

8.1 rtCommon

8.1.1 Submodules

8.1.1.1 rtCommon.addLogin

A command-line script to add or change a user/password for access to the web portal. The password file is store in rt-cloud/certs/passwd

Examples

$ python addLogin.py # username and password will be requested at prompt $ python addLogin.py -u <username> -p <password> $ python addLogin.py -username <username> -password <password>

Module Contents

Functions

addUserPassword(username, password, pwdFile, retypePasswd=True)	
main(username, password)	

[1] Created with sphinx-autoapi

Attributes

currPath
rootPath
passwordFile
argParser

rtCommon.addLogin.**currPath**

rtCommon.addLogin.**rootPath**

rtCommon.addLogin.**passwordFile = certs/passwd**

rtCommon.addLogin.**addUserPassword**(*username*, *password*, *pwdFile*, *retypePasswd=True*)

rtCommon.addLogin.**main**(*username*, *password*)

rtCommon.addLogin.**argParser**

8.1.1.2 rtCommon.bidsArchive

bidsArchive.py

Implements interacting with an on-disk BIDS Archive.

Module Contents

Classes

BidsArchive

Functions

failIfEmpty(func)

Attributes

logger

rtCommon.bidsArchive.**logger**

rtCommon.bidsArchive.**failIfEmpty**(*func*)

class rtCommon.bidsArchive.**BidsArchive**(*rootPath: str*)

__str__(*self*)

Return str(self).

__getattr__(*self*, *attr*)

static **_stripLeadingSlash**(*path: str*) → str

Strips a leading / from the path, if it exists. This prevents paths defined relative to dataset root (/sub-01/ses-01) from being interpreted as being relative to the root of the filesystem.

Parameters

path – Path to strip leading slash from.

Examples

```
>>> path = '/sub-01/ses-01/func/sub-01_task-test_bold.nii.gz'
>>> BidsArchive._stripLeadingSlash(path)
'sub-01/ses-01/func/sub-01_task-test_bold.nii.gz'
>>> path = 'sub-01/ses-01/func/sub-01_task-test_bold.nii.gz'
'sub-01/ses-01/func/sub-01_task-test_bold.nii.gz'
```

absPathFromRelPath(*self*, *relPath: str*) → str

Makes an absolute path from the relative path within the dataset.

tryGetFile(*self*, *path: str*) → bids.layout.BIDSFile

Tries to get a file from the archive using different interpretations of the target path. Interpretations considered are: 1) Path with leading slash, relative to filesystem root 2) Path with leading slash, relative to archive root 3) Path with no leading slash, assume relative to archive root

Parameters

path – Path to the file to attempt to get.

Returns

BIDSFile (or subclass) if a matching file was found, None otherwise.

Examples

```
>>> archive = BidsArchive('/path/to/archive')
>>> filename = 'sub-01_task-test_bold.nii.gz'
>>> archive.tryGetFile('/tmp/archive/sub-01/func/' + filename)
<BIDSImageFile filename=/tmp/archive/sub-01/func/sub-01_task-test
↪bold.nii.gz
>>> archive.tryGetFile('/' + filename)
<BIDSImageFile filename=/tmp/archive/sub-01/func/sub-01_task-test
↪bold.nii.gz
>>> archive.tryGetFile(filename)
<BIDSImageFile filename=/tmp/archive/sub-01/func/sub-01_task-test
↪bold.nii.gz
```

dirExistsInArchive(*self*, *relPath: str*) → bool

getReadme(*self*) → bids.layout.BIDSFile

getImages(*self*, *matchExact: bool = False*, ***entities*) → List[bids.layout.BIDSImageFile]

Return all images that have the provided entities. If no entities are provided, then all images are returned.

Parameters

- **matchExact** – Only return images that have exactly the provided entities, no more and no less.
- ****entities** – Entities that returned images must have.

Returns

A list of images matching the provided entities (empty if there are no matches, and containing at most a single image if an exact match is requested).

Examples

```
>>> archive = BidsArchive('/path/to/archive')
```

Using a dictionary to provide target entities.

```
>>> entityDict = {'subject': '01', 'datatype': 'func'}
>>> images = archive.getImages(**entityDict)
```

Using keyword arguments to provide target entities.

```
>>> images = archive.getImages(subject='01', datatype='func')
```

Accessing properties of the image.

```
>>> image = images[0]
>>> print(image.get_image()
(64, 64, 27, 3)
>>> print(image.path)
/tmp/archive/func/sub-01_task-test_bold.nii
>>> print(image.filename)
sub-01_task-test_bold.nii
```

An exact match must have exactly the same entities; since images must also have the task entity in their filename, the above entityDict will yield no exact matches in the archive.

```
>>> images = archive.getImages(entityDict, matchExact=True)
ERROR "No images were an exact match for: {'subject': '01',
'datatype': 'func'}"
>>> print(len(images))
0
```

_updateLayout(*self*)

Updates the layout of the dataset so that any new metadata or image files are added to the index.

_addImage(*self*, *img: nibabel.Nifti1Image*, *path: str*, *updateLayout: bool = True*) → None

Replace the image in the dataset at the provided path, creating the path if it does not exist.

Parameters

- **img** – The image to add to the archive
- **path** – Relative path in archive at which to add image
- **updateLayout** – Update the underlying layout object upon conclusion of the image addition.

_addMetadata(*self*, *metadata: dict*, *path: str*, *updateLayout: bool = True*) → None

Replace the sidecar metadata in the dataset at the provided path, creating the path if it does not exist.

Parameters

- **metadata** – Metadata key/value pairs to add.
- **path** – Relative path in archive at which to add image
- **updateLayout** – Update the underlying layout object upon conclusion of the metadata addition.

isEmpty(*self*) → bool

getSidecarMetadata(*self*, *image: Union[str, bids.layout.BIDSImageFile]*, *includeEntities: bool = True*) → dict

Get metadata for the file at the provided path in the dataset. Sidecar metadata is always returned, and BIDS entities present in the filename are returned by default (this can be disabled).

Parameters

- **image** – Path or BIDSImageFile pointing to the image file to get metadata for.
- **includeEntities** – False to return only the metadata in the image's sidecar JSON files. True to additionally include the entities in the filename (e.g., 'subject', 'task', and 'session'). Defaults to True.

Raises

TypeError – If image is not a str or BIDSImageFile.

Returns

Dictionary with sidecar metadata for the file and any metadata that
can be extracted from the filename (e.g., subject, session).

Examples

```
>>> archive = BidsArchive('/path/to/archive')
>>> path = archive.getImages()[0].path
>>> archive.getSidecarMetadata(path)
{'AcquisitionMatrixPE': 320, 'AcquisitionNumber': 1, ... }
```

getEvents(*self*, *matchExact: bool = False*, ***entities*) → List[bids.layout.BIDSDataFile]

Gets data from scanner run event files in the archive. Event files to retrieve can be filtered by entities present in the files' names.

Parameters

- **matchExact** – Whether to only return events files that have exactly the same entities as provided (no more, no less)
- **entities** – Keyword arguments for entities to filter by. Provide in the format entity='value'.

Returns

A list of BIDSDataFile objects encapsulating the events files matching the provided entities (empty if there are no matches, and containing at most a single object if an exact match is requested).

Raises

ValueError – If the 'extension' entity is provided and not valid for an events file (i.e., not '.tsv' or '.tsv.gz')

Examples

```
>>> archive = BidsArchive('.')
>>> archive.getEvents()
[<BIDSDataFile filename='/tmp/dataset/sub-01/func/           sub-01_task-test_
↪events.tsv'>, <BIDSDataFile
filename='/tmp/dataset/sub-02/func/sub-02_task-test_events.tsv'>]
>>> sub1Events = archive.getEvents(subject='01')
[<BIDSDataFile filename='/tmp/dataset/sub-01/func/           sub-01_task-test_
↪events.tsv'>]
>>> eventsDataFrame = sub1Events[0].get_df()
>>> print(eventsDataFrame[:][:1])
    onset   duration    trial_type
0   0       30          rest
```

_appendIncremental(*self*, *incremental: rtCommon.bidsIncremental.BidsIncremental*, *makePath: bool = True*, *validateAppend: bool = True*) → bool

Appends a BIDS Incremental's image data and metadata to the archive, creating new directories if necessary (this behavior can be overridden). For internal use only.

Parameters

- **incremental** – BIDS Incremental to append
- **makePath** – Create new directory path for BIDS-I data if needed. (default: True).
- **validateAppend** – Compares image metadata and NIfTI headers to check that the images being appended are part of the same sequence and don't conflict with each other (default: True).

Raises

- **RuntimeError** – If the image to append to in the archive is not either 3D or 4D.
- *StateError* – If the image path within the BIDS-I would result in directory creation and makePath is set to False.
- *ValidationError* – If the data to append is incompatible with existing data in the archive.

Returns
True if the append succeeded, False otherwise.

Examples

Assume we have a NIfTI image 'image' and a metadata dictionary 'metdata' with all required metadata for a BIDS Incremental.

```
>>> archive = BidsArchive('.')
>>> incremental = BidsIncremental(image, metadata)
>>> archive._appendIncremental(incremental)
```

If we don't want to create any new files/directories in the archive, makePath can be set to false.

```
>>> archive = BidsArchive('/tmp/emptyDirectory')
>>> archive._appendIncremental(incremental, makePath=False)
False
```

_getIncremental(*self*, *imageIndex: int = 0*, ***entities*) → *rtCommon.bidsIncremental.BidsIncremental*
Creates a BIDS Incremental from the specified part of the archive. For internal use only.

Parameters

- **imageIndex** – Index of 3-D image to select in a 4-D image volume.
- **entities** – Keyword arguments for entities to filter by. Provide in the format entity='value'.

Returns
BIDS-Incremental file with the specified image of the archive and its associated metadata.

Raises

- **IndexError** – If the provided imageIndex goes beyond the bounds of the volume specified in the archive.
- *MissingMetadataError* – If the archive lacks the required metadata to make a BIDS Incremental out of an image in the archive.
- **NoMatchError** – When no images that match the provided entities are found in the archive
- **RuntimeError** – 1) When too many images that match the provided entities are found in the archive. 2) If the image matching the provided entities has fewer than 3 dimensions or greater than 4.

Examples

```
>>> archive = BidsArchive('.')
>>> inc = archive._getIncremental(subject='01', task='test')
>>> entityFilterDict = {'subject': '01', 'task': 'test'}
>>> inc2 = archive._getIncremental(**entityFilterDict)
>>> inc == inc2
True
```

By default, _getIncremental has an imageIndex of 0. Changing that parameter will return a different 3-D image from the volume, using the same search metadata.

```
>>> inc.getImageDimensions()
(64, 64, 27, 1)
>>> inc3 = archive._getIncremental(imageIndex=1, **entityFilterDict)
>>> inc2 != inc3
True
```

getBidsRun(*self*, ***entities*) → *rtCommon.bidsRun.BidsRun*

Get a BIDS Run from the archive.

Parameters
`entities` – Entities defining a run in the archive.

Returns
A BidsRun containing all the BidsIncrementals in the specified run.

Raises

- `NoMatchError` – If the entities don't match any runs in the archive.
- *`QueryError`* – If the entities match more than one run in the archive.

Examples

```
>>> archive = BidsArchive('/tmp/dataset')
>>> run = archive.getBidsRun(subject='01', session='02',
                             task='testTask', run=1)
>>> print(run.numIncrementals())
53
```

appendBidsRun(*self*, *run: rtCommon.bidsRun.BidsRun*) → None

Append a BIDS Run to this archive.

Parameters
`run` – Run to append to the archvie.

Examples

```
>>> archive1 = BidsArchive('/tmp/dataset1')
>>> archive2 = BidsArchive('/tmp/dataset2')
>>> archive1.getRuns()
[1, 2]
>>> archive2.getRuns()
[1]
>>> run2 = archive1.getBidsRun(subject='01', task='test', run=2)
>>> archive2.appendBidsRun(run2)
>>> archive2.getRuns()
[1, 2]
```

8.1.1.3 rtCommon.bidsCommon

bidsCommon.py

Shared constants and functions used by modules working with BIDS data.

Module Contents

Classes

BidsFileExtension	Generic enumeration.
BidsEntityKeys	Generic enumeration.

Functions

`loadBidsEntities`() → dict	Loads all accepted BIDS entities from PyBids into a dictionary.
`filterEntities`(metadata: dict) → dict	Returns a new dictionary containing all the elements of the argument that
`getNiftiData`(image: nibabel.Nifti1Image) → numpy.ndarray	Nibabel exposes a get_fdata() method, but this converts all the data to
`makeDicomFieldBidsCompatible`(dicomField: str) → str	Remove non-alphanumeric characters to make a DICOM field name
`correct3DHeaderTo4D`(image: nibabel.Nifti1Image, repetitionTime: int, timeUnitCode: int = 8) → None	Makes necessary changes to the NIfTI header to reflect the increase in its
`adjustTimeUnits`(imageMetadata: dict) → None	Validates and converts in-place the units of various time-based metadata,
`metadataFromProtocolName`(protocolName: str) → dict	Extracts BIDS label-value combinations from a DICOM protocol name, if
`getDicomMetadata`(dicomImg: pydicom.dataset.Dataset, kind='all') → dict	Returns the public (even-numbered tags) and private (odd-numbered tags)
`symmetricDictDifference`(d1: dict, d2: dict, equal: Callable[[Any, Any], bool] = opeq) → dict	Returns the symmetric difference of the provided dictionaries. This
`niftiHeadersAppendCompatible`(header1: dict, header2: dict)	Verifies that two Nifti image headers match in along a defined set of
`niftiImagesAppendCompatible`(img1: nibabel.Nifti1Image, img2: nibabel.Nifti1Image) → Tuple[bool, str]	Verifies that two Nifti images have headers matching along a defined set of
`metadataAppendCompatible`(meta1: dict, meta2: dict) → Tuple[bool, str]	Verifies two metadata dictionaries match in a set of required fields. If a
`correctEventsFileDatatypes`(df: pandas.DataFrame) → pandas.DataFrame	
`writeDataFrameToEvents`(df: pandas.DataFrame, path: str) → None	

Attributes

logger	
BIDS_VERSION	
DATASET_DESC_REQ_FIELDS	
DEFAULT_DATASET_DESC	
DEFAULT_README	
DEFAULT_EVENTS_HEADERS	
BIDS_FILE_PATTERN	
BIDS_DIR_PATH_PATTERN	
BIDS_FILE_PATH_PATTERN	
PYBIDS_PSEUDO_ENTITIES	
BIDS_EVENT_COL_TO_DTYPE	
BidsAttributesToAnonymize	
UNIT_TO_CODE	
CODE_TO_UNIT	

rtCommon.bidsCommon.**logger**

rtCommon.bidsCommon.**BIDS_VERSION = 1.4.1**

rtCommon.bidsCommon.**DATASET_DESC_REQ_FIELDS = ['Name', 'BIDSVersion']**

rtCommon.bidsCommon.**DEFAULT_DATASET_DESC**

rtCommon.bidsCommon.**DEFAULT_README = Generated BIDS-Incremental Dataset from RT-Cloud**

rtCommon.bidsCommon.**DEFAULT_EVENTS_HEADERS = ['onset', 'duration']**

rtCommon.bidsCommon.**BIDS_FILE_PATTERN =**
sub-{subject}[_ses-{session}]_task-{task}[_acq-{acquisition}][_ce-{ceagent}][_dir-{direction}][_r.
..

rtCommon.bidsCommon.**BIDS_DIR_PATH_PATTERN =**
sub-{subject}[/ses-{session}]/{datatype<func>|func}

rtCommon.bidsCommon.**BIDS_FILE_PATH_PATTERN**

rtCommon.bidsCommon.**PYBIDS_PSEUDO_ENTITIES = ['extension']** `rtCommon.bidsCommon.BIDS_EVENT_COL_TO_DTYPE`

`rtCommon.bidsCommon.BidsAttributesToAnonymize = ['PatientID', 'PatientsAge', 'PatientsBirthDate', 'PatientsName', 'PatientsSex', 'PatientsSize',...`

`class rtCommon.bidsCommon.BidsFileExtension`

Bases: `enum.Enum`

Generic enumeration.

Derive from this class to define new enumerations.

`IMAGE = .nii`

`IMAGE_COMPRESSED = .nii.gz`

`METADATA = .json`

`EVENTS = .tsv`

`class rtCommon.bidsCommon.BidsEntityKeys`

Bases: `enum.Enum`

Generic enumeration.

Derive from this class to define new enumerations.

`ENTITY = entity`

`FORMAT = format`

`DESCRIPTION = description`

`rtCommon.bidsCommon.loadBidsEntities()` → dict

Loads all accepted BIDS entities from PyBids into a dictionary.

Returns

A dictionary mapping the entity names to the PyBids Entity object containing information about that entity.

`rtCommon.bidsCommon.filterEntities`(*metadata: dict*) → dict

Returns a new dictionary containing all the elements of the argument that are valid BIDS entities.

`rtCommon.bidsCommon.getNiftiData`(*image: nibabel.Nifti1Image*) → numpy.ndarray

Nibabel exposes a get_fdata() method, but this converts all the data to float64. Since our Nifti files are often converted from DICOM's, which store data in signed or unsigned ints, treating the data as float can cause issues when comparing images or re-writing a Nifti read in from disk.

`rtCommon.bidsCommon.makeDicomFieldBidsCompatible`(*dicomField: str*) → str

Remove non-alphanumeric characters to make a DICOM field name BIDS-compatible (CamelCase alphanumeric) metadata field. Note: Multi-word keys like 'Frame of Reference UID' become 'FrameofReferenceUID', which might be different than the expected behavior

Parameters

dicomField – Name of the DICOM field to convert to BIDS format

Returns

DICOM field name in BIDS-compatible format.

Examples

```
>>> field = "Repetition Time"
>>> makeDicomFieldBidsCompatible(field)
'RepetitionTime'
```

rtCommon.bidsCommon.**UNIT_TO_CODE**

rtCommon.bidsCommon.**CODE_TO_UNIT**

rtCommon.bidsCommon.**correct3DHeaderTo4D**(*image: nibabel.Nifti1Image*, *repetitionTime: int*, *timeUnitCode: int = 8*) → None

Makes necessary changes to the NIfTI header to reflect the increase in its corresponding image's data shape from 3D to 4D.

Parameters

- **image** – NIfTI image to modify header for
- **repetitionTime** – Repetition time for the scan that produced the image
- **timeUnitCode** – The temporal dimension NIfTI unit code (e.g., millimeters is 2, seconds is 8). Defaults to seconds.

rtCommon.bidsCommon.**adjustTimeUnits**(*imageMetadata: dict*) → None

Validates and converts in-place the units of various time-based metadata, which is stored in seconds in BIDS, but often provided using milliseconds in DICOM.

rtCommon.bidsCommon.**metadataFromProtocolName**(*protocolName: str*) → dict

Extracts BIDS label-value combinations from a DICOM protocol name, if any are present.

Returns
A dictionary containing any valid label-value combinations found.

rtCommon.bidsCommon.**getDicomMetadata**(*dicomImg: pydicom.dataset.Dataset*, *kind='all'*) → dict

Returns the public (even-numbered tags) and private (odd-numbered tags) metadata from the provided DICOM image.

Parameters

- **dicomImg** – A Pydicom object to read metadata from.
- **kind** – Metadata category to get. 'public' for public DICOM tags, 'private' for private DICOM tags, 'all' for all DICOM tags.

Returns
Dictionary containing requested metadata from the DICOM image.

Raises
TypeError – If the image provided is not a pydicom.dataset.Dataset object (e.g., if the image were the raw DICOM data).

rtCommon.bidsCommon.**symmetricDictDifference**(*d1: dict*, *d2: dict*, *equal: Callable[[Any, Any], bool] = opeq*) → dict

Returns the symmetric difference of the provided dictionaries. This consists of 3 parts: 1) Key-value pairs for which both dictionaries have the key, but have different values for that key. 2) All key-value pairs that only the first dictionary has. 3) All key-value pairs that only the second dictionary has.

Parameters

- **d1** – First dictionary

- **d2** – Second dictionary
- **equal** – Function that returns True if two keys are equal, False otherwise

Returns
A dictionary with all key-value pair differences between the two dictionaries. 'None' is used as the value for a key-value pair if that dictionary lacks a key that the other one has.

Examples

```
>>> d1 = {'a': 1, 'b': 2, 'c': 3}
>>> d2 = {'c': 4, 'd': 5}
>>> print(symmetricDictDifference(d1, d2))
{'a': [1, None], 'b': [2, None], 'c': [3, 4], 'd': [None, 5]}
>>> d2 = {'a': 1, 'b': 2, 'c': 4}
>>> print(symmetricDictDifference(d1, d2))
{'c': [3, 4]}
```

`rtCommon.bidsCommon.`**`niftiHeadersAppendCompatible`**(*header1: dict*, *header2: dict*)

Verifies that two Nifti image headers match in along a defined set of NIfTI header fields which should not change during a continuous fMRI scanning session.

This is primarily intended as a safety check, and does not conclusively determine that two images are valid to append to together or are part of the same scanning session.

Parameters

- **header1** – First Nifti header to compare (dict of numpy arrays)
- **header2** – Second Nifti header to compare (dict of numpy arrays)

Returns
True if the headers match along the required dimensions, False otherwise.

`rtCommon.bidsCommon.`**`niftiImagesAppendCompatible`**(*img1: nibabel.Nifti1Image*, *img2: nibabel.Nifti1Image*) → Tuple[bool, str]

Verifies that two Nifti images have headers matching along a defined set of NIfTI header fields which should not change during a continuous fMRI scanning session.

This is primarily intended as a safety check, and does not conclusively determine that two images are valid to append to together or are part of the same scanning session.

Parameters

- **img1** – First Nifti image to compare
- **img2** – Second Nifti image to compare

Returns

True if the image headers match along the required dimensions, False
otherwise.

`rtCommon.bidsCommon.`**`metadataAppendCompatible`**(*meta1: dict*, *meta2: dict*) → Tuple[bool, str]

Verifies two metadata dictionaries match in a set of required fields. If a field is present in only one or neither of the two dictionaries, this is considered a match.

This is primarily intended as a safety check, and does not conclusively determine that two images are valid to append to together or are part of the same series.

Parameters

- **meta1** – First metadata dictionary
- **meta2** – Second metadata dictionary

Returns

True if all keys that are present in both dictionaries have equivalent values, false otherwise.

rtCommon.bidsCommon.**correctEventsFileDatatypes**(*df: pandas.DataFrame*) → pandas.DataFrame

rtCommon.bidsCommon.**writeDataFrameToEvents**(*df: pandas.DataFrame*, *path: str*) → None

8.1.1.4 rtCommon.bidsIncremental

bidsIncremental.py

Implements the BIDS Incremental data type used for streaming BIDS data between different applications.

Module Contents

Classes

BidsIncremental

Attributes

logger

rtCommon.bidsIncremental.**logger**

class rtCommon.bidsIncremental.**BidsIncremental**(*image: nibabel.Nifti1Image*, *imageMetadata: dict*, *datasetDescription: dict = None*)

ENTITIES

REQUIRED_IMAGE_METADATA = ['subject', 'task', 'suffix', 'datatype', 'RepetitionTime']

BIDS Incremental data format suitable for streaming BIDS Archives

_imgMetadata

Store dataset description

__str__(*self*)

Return str(self).

__eq__(*self*, *other*)

Return self==value.

__getstate__(*self*)

__setstate__(*self*, *state*)

_preprocessMetadata(*self*, *imageMetadata: dict*) → dict

Pre-process metadata to extract any additonal metadata that might be embedded in the provided metadata, like ProtocolName, and ensure that certain metadata values (e.g., RepetitionTime) are within BIDS-specified ranges.

Parameters

imageMetadata – Metadata dictionary provided to BIDS incremental to search for additional, embedded metadata

Returns

Original dictionary with all embedded metadata added explicitly and
values within BIDS-specified ranges.

_exceptIfMissingMetadata(*self*, *imageMetadata: dict*) → None

Ensure that all required metadata is present.

Parameters

imageMetadata – Metadata dictionary to check for missing metadata

Raises

MissingMetadataError – If not all required metadata is present.

_postprocessMetadata(*self*, *imageMetadata: dict*) → dict

Post-process metadata once all required fields are given (e.g., to create derived fields like 'TaskName' from 'task').

Parameters

imageMetadata – Metadata dictionary to post-process.

Returns

Metadata dictionary with derived fields set.

static **createImageMetadataDict**(*subject: str*, *task: str*, *suffix: str*, *datatype: str*, *repetitionTime: int*)

Creates an image metadata dictionary for a BIDS-I with all of the basic required fields using the correct key names.

Parameters

- **subject** – Subject ID (e.g., '01')
- **task** – Task ID (e.g., 'story')
- **suffix** – Imaging method (e.g., 'bold')
- **datatype** – Data type (e.g., 'func' or 'anat')
- **repetitionTime** – TR time, in seconds, used for the imaging run

Returns

Dictionary with the provided information ready for use in a BIDS-I

classmethod **findMissingImageMetadata**(*cls*, *imageMeta: dict*) → list

Creates a list of all required metadata fields that the argument dictionary is missing.

Parameters
: **imageMeta** – Metadata dictionary to check for missing fields

Returns
: List of required fields missing in the provided dictionary.

Examples

```
>>> meta = {'subject': '01', 'task': 'test', 'suffix': 'bold',
            'datatype': 'func'}
>>> BidsIncremental.findMissingImageMetadata(meta)
['RepetitionTime']
```

classmethod isCompleteImageMetadata(*cls*, *imageMeta: dict*) → bool

Verifies that all required metadata fields for BIDS-I construction are present in the dictionary.

Parameters
: **imageMeta** – The dictionary with the metadata fields

Returns
: True if all required fields are present in the dictionary, False otherwise.

Examples

```
>>> meta = {'subject': '01', 'task': 'test', 'suffix': 'bold',
            'datatype': 'func'}
>>> BidsIncremental.isCompleteImageMetadata(meta)
False
```

_exceptIfNotBids(*self*, *entityName: str*) → None

Raise an exception if the argument is not a valid BIDS entity

getMetadataField(*self*, *field: str*, *strict: bool = False*) → Any

Get value for the field in the incremental's metadata, if it exists.

Parameters

- **field** – Metadata field to retrieve a value for.
- **default** – Default value to return if field is not present.
- **strict** – Only allow getting fields that are defined as BIDS entities in the standard.

Returns
: Entity's value, or None if the entity isn't present in the metadata.

Raises

- **ValueError** – If 'strict' is True and 'field' is not a BIDS entity.
- **KeyError** – If the field is not present in the Incremental's metadata and not default value is provided.

Examples

```
>>> incremental.getMetadataField('task')
'faces'
>>> incremental.getMetadataField('RepetitionTime')
1.5
>>> incremental.getMetadataField('RepetitionTime', strict=True)
ValueError: RepetitionTime is not a valid BIDS entity name
```

setMetadataField(*self*, *field: str*, *value: Any*, *strict: bool = False*) → None

Set metadata field to provided value in Incremental's metadata.

Parameters

- **field** – Metadata field to set value for.
- **value** – Value to set for the provided entity.
- **strict** – Only allow setting fields that are defined as BIDS entities in the standard.

Raises

ValueError – If 'strict' is True and 'field' is not a BIDS entity.

removeMetadataField(*self*, *field: str*, *strict: bool = False*) → None

Remove a piece of metadata from the incremental's metadata.

Parameters

- **field** – BIDS entity name to retrieve a value for.
- **strict** – Only allow removing fields that are defined as BIDS entities in the standard.

Raises

- **ValueError** – If 'strict' is True and 'field' is not a BIDS entity.
- **RuntimeError** – If the field to be removed is required by the Incremental.

getImageMetadata(*self*)

getSuffix(*self*) → str

getDatatype(*self*) → str

func or anat

getEntities(*self*) → dict

getImageDimensions(*self*) → tuple

getImageHeader(*self*)

getImageData(*self*) → numpy.ndarray

makeBidsFileName(*self*, *extension: rtCommon.bidsCommon.BidsFileExtension*) → str

Create the a BIDS-compatible file name based on the metadata. General format of the filename, per BIDS standard 1.4.1, is as follows (items in [square brackets] are considered optional):

sub-<label>[_ses-<label>]_task-<label>[_acq-<label>] [_ce-<label>] [_dir-<label>][_rec-<label>][_run-<index>] [_echo-<index>]_<contrast_label >.ext

Parameters

extension – The extension for the file, e.g., 'nii' for images or 'json' for metadata

Returns
Filename from metadata according to BIDS standard 1.4.1.

getDatasetName(*self*) → str

getImageFileName(*self*) → str

getMetadataFileName(*self*) → str

getEventsFileName(*self*) → str

getImageFilePath(*self*) → str

getMetadataFilePath(*self*) → str

getEventsFilePath(*self*) → str

getDataDirPath(*self*) → str

Path to where this incremental's data would be in a BIDS archive, relative to the archive root.

Returns
Path string relative to root of the imaginary dataset.

Examples

```
>>> print(bidsi.getDataDirPath())
sub-01/ses-2011/anat
```

getAcquisitionTime(*self*) → datetime.datetime.time

Returns the acquisition time as a datetime.time

getRepetitionTime(*self*) → float

Returns the TR repetition time in seconds

timeToNextTr(*self*, *clockSkew*, *now=None*) → float

Based on acquisition time returns seconds to next TR start

writeToDisk(*self*, *datasetRoot: str*, *onlyData=False*) → None

Writes the incremental's data to a directory on disk. NOTE: The directory is assumed to be empty, and no checks are made for data that would be overwritten.

Parameters

- **datasetRoot** – Path to the root of the BIDS archive to be written to.
- **onlyData** – Only write out the NIfTI image and sidecar metadata (Default False). Useful if writing an incremental out to an existing archive and you don't want to overwrite existing README or dataset_description.json files.

Examples

```
>>> from bidsArchive import BidsArchive
>>> incremental = BidsIncremental(image, metadata)
>>> root = '/tmp/emptyDirectory'
>>> incremental.writeToDisk(root)
>>> archive = BidsArchive(root)
>>> print(archive)
Root: /tmp/emptyDirectory | Subjects: 1 | Sessions: 1 | Runs: 1
```

8.1.1.5 `rtCommon.bidsInterface`

BidsInterface is a client interface (i.e. for the experiment script running in the cloud) that provides data access to BIDS data.

To support RPC calls from the client, there will be two instances of dataInterface, one at the cloud projectServer which is a stub to forward requests (started with dataRemote=True), and another at the control room computer, run as a service and with dataRemote=False.

When not using RPC, i.e. when the projectServer is run without –dataRemote, there will be only one instance of dataInterface, as part of the projectServer with dataRemote=False.

Module Contents

Classes

BidsInterface	Provides functions for accessing remote or local BIDS data depending on if dataRemote flag
DicomToBidsStream	A class that watches for DICOM file creation in a specified directory and with
BidsStream	A class that opens a BIDS archive and prepares to stream the data as

class rtCommon.bidsInterface.**BidsInterface**(*dataRemote=False*, *allowedDirs=[]*, *scannerClockSkew=0*)

Bases: *rtCommon.remoteable.RemoteableExtensible*

Provides functions for accessing remote or local BIDS data depending on if dataRemote flag is set true or false.

If dataRemote=True, then the RemoteExtensible parent class takes over and forwards all requests to a remote server via a callback function registered with the RemoteExtensible object. In that case *none* of the methods below will be locally invoked.

If dataRemote=False, then the methods below will be invoked locally and the RemoteExtensible parent class is inoperable (i.e. does nothing).

initDicomBidsStream(*self*, *dicomDir*, *dicomFilePattern*, *dicomMinSize*, *anonymize=True*, ***entities*) → int

Intialize a data stream that watches a directory for DICOM files to be written that match the given file pattern. When a DICOM is written it will be converted to a BIDS incremental and returned.

Parameters

- **dicomDir** – the directory where the images are or will be written from the MRI scanner.

- **dicomFilePattern** – a pattern of the image file names that has a TR tag which will be used to index the images, for example 'scan01_{TR:03d}.dcm'. In this example a call to getImageData(imgIndex=6) would look for dicom file 'scan01_006.dcm'.
- **minFileSize** – Minimum size of the file to return (continue waiting if below this size)
- **anonymize** – Whether to remove participant specific fields from the Dicom header
- **entities** – BIDS entities (subject, session, task, run, suffix, datatype) that will be required to fill in the BIDS metadata in the BIDS Incremental

Returns
An int identifier to be used when calling stream functions, such as getIncremental()

Return type
streamId

`initBidsStream`(*self*, *archivePath*, ***entities*) → int

Initialize a data stream from an existing BIDS archive.

Parameters

- **archivePath** – Full path to the BIDS archive
- **entities** – BIDS entities (subject, session, task, run, suffix, datatype) that define the particular subject/run of the data to stream

Returns
An int identifier to be used when calling stream functions, such as getIncremental()

Return type
streamId

`initOpenNeuroStream`(*self*, *dsAccessionNumber*, ***entities*) → int

Initialize a data stream that replays an OpenNeuro dataset.

Parameters

- **dsAccessionNumber** – OpenNeuro accession number of the dataset to replay
- **entities** – BIDS entities (subject, session, task, run, suffix, datatype) that define the particular subject/run of the data to stream

Returns
An identifier used when calling stream functions, such as getIncremental()

Return type
streamId

`getIncremental`(*self*, *streamId*, *volIdx=- 1*, *timeout=5*, *demoStep=0*) → *rtCommon.bidsIncremental.BidsIncremental*

Get a BIDS Incremental from a stream

Parameters

- **streamId** – The stream handle returned by the initXXStream call
- **volIdx** – The brain volume index of the image to return. If -1 is entered it will return the next volume
- **timeout** – Max number of seconds to wait for incremental when running real-time
- **demoStep** – Simulate x second TR delay

Returns
A BidsIncremental containing the image volume

`getNumVolumes`(*self*, *streamId*) → int

Return the number of image volumes contained in the stream. This is only defined for Bids/OpenNeuro streams (not for DicomBidsStreams)

Parameters
`streamId` – The stream handle returned by the initXXStream call

Returns
An int of the number of volumes

`closeStream`(*self*, *streamId*)

`getClockSkew`(*self*, *callerClockTime: float*, *roundTripTime: float*) → float

Returns the clock skew between the caller's computer and the scanner clock. This function is assumed to be running in the scanner room and have adjustments to translate this server's clock to the scanner clock. Value returned is in seconds. A positive number means the scanner clock is ahead of the caller's clock. The caller should add the skew to their localtime to get the time in the scanner's clock.

Parameters

- `time` (*callerClockTime - current*) –
- `caller` (*roundTripTime - measured RTT in seconds to remote*) –

Returns
Clockskew - seconds the scanner's clock is ahead of the caller's clock

`ping`(*self*) → float

Returns seconds since the epoch

`class rtCommon.bidsInterface.DicomToBidsStream`(*allowedDirs=[]*)

A class that watches for DICOM file creation in a specified directory and with a specified file pattern. When DICOM files arrive it converts them to BIDS incrementals and returns the BIDS incremental. This lets a real-time classification script process data directly as BIDS as it arrives from the scanner.

`initStream`(*self*, *dicomDir*, *dicomFilePattern*, *dicomMinSize*, *anonymize=True*, ***entities*)

Intialize a new DicomToBids stream, watches for Dicoms and streams as BIDS

Parameters

- `dicomDir` – The directory where the scanner will write new DICOM files
- `dicomFilePattern` – A regex style pattern of the DICOM filenames to watch for. They should include a {TR} tag with optional formatting. For example filenames like '001_000013_000005.dcm' would have a pattern '001_000013_{TR:06d}.dcm' where the volume number (TR) will be filled in by a 6 digit leading zeros value.
- `dicomMinSize` – Minimum size of the file to return (will continue waiting if below this size)
- `anonymize` – Whether to remove participant specific fields from the Dicom header
- `entities` – BIDS entities (subject, session, task, run, suffix, datatype) that define the particular subject/run of the data to stream

`abstract getNumVolumes`(*self*) → int

Return the number of brain volumes in the run, unknowable by this interface ahead of time for a real-time DICOM stream `getIncremental`(*self*, *volIdx=- 1*, *timeout=5*, *demoStep=0*) → *rtCommon.bidsIncremental.BidsIncremental*

Get the BIDS incremental for the corresponding DICOM image indicated by the volIdx, where volIdx is equivalent to TR id.

VolIdx acts similar to a file_seek pointer. If a volIdx >= 0 is supplied the volume pointer is advanced to that position. If no volIdx or a volIdx < 0 is supplied, then the next image volume after the previous position is returned and the pointer is incremented.

Parameters

- **volIdx** – The volume index (or TR) within the run to retrieve.
- **timeout** – Max number of seconds to wait for incremental

Returns
BidsIncremental for the matched DICOM for the run/volume

class `rtCommon.bidsInterface.BidsStream`(*archivePath*, ***entities*)

A class that opens a BIDS archive and prepares to stream the data as BIDS incrementals.

`getNumVolumes`(*self*) → int

Return the number of brain volumes in the run

`getIncremental`(*self*, *volIdx=- 1*, *timeout=5*, *demoStep=0*) → *rtCommon.bidsIncremental.BidsIncremental*

Get a BIDS incremental for the indicated index in the current subject/run VolIdx acts similar to a file_seek pointer. If a volIdx >= 0 is supplied the volume pointer is advanced to that position. If no volIdx or a volIdx < 0 is supplied, then the next image volume after the previous position is returned and the pointer is incremented.

Parameters

- **volIdx** – The volume index (or TR) within the run to retrieve.
- **timeout** – Not used but present to support calling convention of other stream types

Returns
BidsIncremental of that volume index within this subject/run

8.1.1.6 `rtCommon.bidsRun`

---

bidsRun.py

Implements the BIDS Run data type used for representing full fMRI scanning runs as sequences of BIDS incrementals.

Module Contents

Classes

BidsRun

Attributes

logger

`rtCommon.bidsRun.logger`

`class rtCommon.bidsRun.BidsRun(**entities)`

`__eq__`(*self*, *other*)

Return self==value.

`getIncremental`(*self*, *index: int*) → *rtCommon.bidsIncremental.BidsIncremental*

Returns the incremental in the run at the provided index.

Parameters
`index` – Which image of the run to get (0-indexed)

Returns
Incremental at provided index.

Raises
`IndexError` – If index is out of bounds for this run.

Examples

```
>>> print(run.numIncrementals())
5
>>> inc = run.getIncremental(1)
>>> inc2 = run.getIncremental(5)
IndexError
```

`appendIncremental`(*self*, *incremental:* rtCommon.bidsIncremental.BidsIncremental, *validateAppend: bool = True*) → None

Appends an incremental to this run's data, setting the run's entities if the run is empty.

Parameters

- `incremental` – The incremental to add to the run.
- `validateAppend` – Validate the incremental matches the current run's data (default True). Turning off is useful for efficiently creating a whole run at once from an existing image volume, where all data is known to be match already.

Raises
MetadataMismatchError – If either the incremental's entities, its images's NIfTI header, or its metadata doesn't match the existing run's data.

Examples

Suppose a NIfTI image and metadata dictionary are available in the environment.

```
>>> incremental = BidsIncremental(image, metadata)
>>> run = BidsRun()
>>> run.appendIncremental(incremental)
>>> metadata['subject'] = 'new_subject'
>>> incremental2 = BidsIncremental(image, metadata)
>>> run.appendIncremental(incremental2)
MetadataMismatchError
```

asSingleIncremental(*self*) → *rtCommon.bidsIncremental.BidsIncremental*

Coalesces the entire run into a single BIDS-I that can be sent over a network, written to disk, or added to an archive.

Returns

BidsIncremental with all image data and metadata represented by the
incrementals composing the run, or None if the run is empty.

Examples

```
>>> incremental = run.asSingleIncremental()
>>> incremental.writeToDisk('/tmp/new_dataset')
```

numIncrementals(*self*) → int

Returns number of incrementals in this run.

getRunEntities(*self*) → dict

Returns dictionary of the BIDS entities associated with this run.

Examples

```
>>> print(run.getRunEntities())
{'subject': '01', 'session': '01', 'task': 'test', run: 1,
'datatype': 'func', 'suffix': 'bold'}
```

8.1.1.7 rtCommon.certsUtils

Utility functions for using ssl encrypted web connections

Module Contents

Functions

getSslCertFilePath()
getSslKeyFilePath()

Attributes

currPath
rootPath
certsDir
sslCertFile
sslPrivateKey

rtCommon.certsUtils.**currPath**

rtCommon.certsUtils.**rootPath**

rtCommon.certsUtils.**certsDir**

rtCommon.certsUtils.**sslCertFile = rtcloud.crt**

rtCommon.certsUtils.**sslPrivateKey = rtcloud_private.key**

rtCommon.certsUtils.**getSslCertFilePath**()

rtCommon.certsUtils.**getSslKeyFilePath**()

8.1.1.8 rtCommon.checkDicomNiftiConversion

---

checkDicomNiftiConversion.py (Last Updated: 05/26/2020)

The purpose of this script is to check that the nifti file conversion done during real-time in the cloud matches the nifti conversion done during your offline analyses, assuming you used heudiconv or you directly called 'dcm2nix()'. This script addresses the warning you get when you import pydicom.

To run this script, uncomment the lines in 'def main()' below. Complete the sections that need to be filled in, denoted by "[FILL IN]"'". Save this file and then run the script "python checkDicomNiftiConversion.py" in the terminal.

Module Contents

Functions

checkingDicomNiftiConversion(cfg)	Purpose: check the nibabel nifti/dicom conversion method BEFORE using it in
main()	

`rtCommon.checkDicomNiftiConversion.`**`checkingDicomNiftiConversion`**`(`*cfg*`)`

Purpose: check the nibabel nifti/dicom conversion method BEFORE using it in real-time. Here we're assuming you have raw dicoms and the corresponding converted nifti that you used in pilot data collection.

STEPS:

0. set up config
1. get number of TRs from dicom path and nifti path
2. go through each TR in dicom, convert them each to niftis and save
3. load in each nifti into new data matrix
4. compare this to loaded offline nifti file

`rtCommon.checkDicomNiftiConversion.`**`main`**`()`

8.1.1.9 rtCommon.clientInterface

This module will be imported by the experiment script (i.e. client) running in the cloud and provide the interfaces for all functionality provided to the client by the rt-cloud projectServer.

The client script instantiates a clientInterface object. It will automatically connect to the projectServer running on the localhost (i.e. same host as the client). If a connection is established the interfaces listed below will be stubs that forward requests to remote servers that will handle the requsts. If the connection fails (i.e. there is no projectServer running), then local versions of the services will be instantiated, for example to access local files instead of remote files. The user will be prompted if local versions will be used.

Client Service Interfaces provided (i.e. for the classification script client):

dataInterface - to read and write files from the remote server subjectInterface - to send subject feedback and receive responses webInterface - to set browser messages, update plots, send/receive configs

Module Contents

Classes

ClientInterface	This class provides the API that an experiment script can use to communicate with the
WrapRpycObject	Rpyc commands return a rpyc.core.netref object to as a reference to the remote object.

class rtCommon.clientInterface.**ClientInterface**(*rpyc_timeout=120*, *yesToPrompts=False*)

This class provides the API that an experiment script can use to communicate with the project server. It provides both a DataInterface for reading or writing files, and a SubjectInterface for sending/receiving feedback and response to the subject in the MRI scanner.

isDataRemote(*self*)

Will return false if either no project server is running, or if a projectServer is running with data being served locally by the projectServer (remember that the projectServer and classification client script always run on the same computer).

isSubjectRemote(*self*)

Same semantics as isDataRemote above.

isUsingProjectServer(*self*)

class rtCommon.clientInterface.**WrapRpycObject**(*rpycObject*)

Bases: `object`

Rpyc commands return a rpyc.core.netref object to as a reference to the remote object. This class wraps all calls to the remote in order to dereference the rpyc.core.netref and return the actual object using rpyc.classic.obtain(ref)

__getattribute__(*self*, *name*)

Return getattr(self, name).

8.1.1.10 rtCommon.dataInterface

DataInterface is a client interface (i.e. for the experiment script running in the cloud) that provides data access, such as reading and writing files.

To support RPC calls from the client, there will be two instances of dataInterface, one at the cloud projectServer which is a stub to forward requests (started with dataRemote=True), and another at the control room computer, run as a service and with dataRemote=False.

When not using RPC, i.e. when the projectServer is run without –dataRemote, there will be only one instance of dataInterface, as part of the projectServer with dataRemote=False.

Module Contents

Classes

DataInterface	Provides functions for accessing remote or local files depending on if dateRemote flag is

Functions

`uploadFilesFromList`(dataInterface, fileList: List[str], outputDir: str, srcDirPrefix=None) → None	Copies files in fileList from the remote onto the system where this call is being made.
`downloadFilesFromList`(dataInterface, fileList: List[str], outputDir: str, srcDirPrefix=None) → None	Copies files in fileList from this computer to the remote.
`uploadFolderToCloud`(dataInterface, srcDir: str, outputDir: str) → None	Copies a folder (directory) from the remote to the system where this call is run
`uploadFilesToCloud`(dataInterface, srcFilePattern: str, outputDir: str)	Copies files matching (regex) srcFilePattern from the remote onto the system
`downloadFolderFromCloud`(dataInterface, srcDir: str, outputDir: str, deleteAfter=False) → None	Copies a directory from the system where this call is made to the remote system.
`downloadFilesFromCloud`(dataInterface, srcFilePattern: str, outputDir: str, deleteAfter=False) → None	Copies files matching srcFilePattern from the system where this call is made

class `rtCommon.dataInterface.`**`DataInterface`**(*dataRemote: bool = False*, *allowedDirs: List[str] = None*, *allowedFileTypes: List[str] = None*, *scannerClockSkew: float = 0*)

Bases: `rtCommon.remoteable.RemoteableExtensible`

Provides functions for accessing remote or local files depending on if dateRemote flag is set true or false.

If dataRemote=True, then the RemoteExtensible parent class takes over and forwards all requests to a remote server via a callback function registered with the RemoteExtensible object. In that case *none* of the methods below will be locally invoked.

If dataRemote=False, then the methods below will be invoked locally and the RemoteExtensible parent class is inoperable (i.e. does nothing).

`__del__`(*self*)

`initScannerStream`(*self*, *imgDir: str*, *filePattern: str*, *minFileSize: int*, *anonymize: bool = True*, *demoStep: int = 0*) → int

Initialize a data stream context with image directory and filepattern. Once the stream is initialized call getImageData() to retrieve image data. NOTE: currently only one stream at a time is supported.

Parameters

- **`imgDir`** – the directory where the images are or will be written from the MRI scanner.
- **`filePattern`** – a pattern of the image file names that has a TR tag which will be used to index the images, for example 'scan01_{TR:03d}.dcm'. In this example a call to getImageData(imgIndex=6) would look for dicom file 'scan01_006.dcm'.
- **`minFileSize`** – Minimum size of the file to return (continue waiting if below this size)
- **`anonymize`** – Whether to remove participant specific fields from the Dicom header

Returns

An identifier used when calling getImageData()

Return type

streamId

`getImageData`(*self*, *streamId: int*, *imageIndex: int = None*, *timeout: int = 5*) → pydicom.dataset.FileDataset

Get data from a stream initialized with initScannerStream

Parameters

- **streamId** – Id of a previously opened stream.
- **imageIndex** – Which image from the stream to retrieve. If left blank it will retrieve the next image in the stream (next after either the last request or starting from 0 if no previous requests)
- **timeout** – Max number of seconds to wait for image data to be available

Returns
The bytes array representing the image data returns pydicom.dataset.FileDataset

getFile(*self*, *filename: str*) → bytes

Returns a file's data immediately or fails if the file doesn't exist.

getNewestFile(*self*, *filepattern: str*) → bytes

Searches for files matching filePattern and returns the data from the newest one.

initWatch(*self*, *dir: str*, *filePattern: str*, *minFileSize: int*, *demoStep: int = 0*) → None

Initialize a watch directory for files matching filePattern.

No data is returned by this function, but a filesystem watch is established. After calling initWatch, use watchFile() to watch for a specific file's arrival.

Parameters

- **dir** – Directory to watch for arrival (creation) of new files
- **filePattern** – Regex style filename pattern of files to watch for (i.e. *.dcm)
- **minFileSize** – Minimum size of the file to return (continue waiting if below this size)
- **demoStep** – Minimum interval (in seconds) to wait before returning files. Useful for demos replaying existing files while mimicking original timing.

watchFile(*self*, *filename: str*, *timeout: int = 5*) → bytes

Watches for a specific file to be created and returns the file data.

InitWatch() must be called first, before watching for specific files. If filename includes the full path, the path must match that used in initWatch().

Parameters

- **filename** – Filename to watch for
- **timeout** – Max number of seconds to wait for file to be available

Returns
The file data

putFile(*self*, *filename: str*, *data: Union[str, bytes]*, *compress: bool = False*) → None

Create a file (filename) and write the bytes or text to it. In remote mode the file is written at the remote.

Parameters

- **filename** – Name of file to create
- **data** – data to write to the file
- **compress** – Whether to compress the data in transit (not within the file), only has affect in remote mode.

listFiles(*self*, *filepattern: str*) → List[str]

Lists files matching the regex filePattern `listDirs`(*self*, *dirpattern: str*) → List[str]

Lists directories matching the regex filePattern

`getAllowedFileTypes`(*self*) → List[str]

Returns the list of file extensions which are allowed for read and write

`getClockSkew`(*self*, *callerClockTime: float*, *roundTripTime: float*) → float

Returns the clock skew between the caller's computer and the scanner clock. This function is assumed to be running in the scanner room and have adjustments to translate this server's clock to the scanner clock. Value returned is in seconds. A positive number means the scanner clock is ahead of the caller's clock. The caller should add the skew to their localtime to get the time in the scanner's clock. :param callerClockTime - current time: :type callerClockTime - current time: secs since epoch :param roundTripTime - measured RTT in seconds to remote caller:

Returns

Clockskew - seconds the scanner's clock is ahead of the caller's clock

`ping`(*self*) → float

Returns seconds since the epoch

`_checkAllowedDirs`(*self*, *dir: str*) → bool

`_checkAllowedFileTypes`(*self*, *filename: str*) → bool

Class-private function for checking if a file is allowed.

`_filterFileList`(*self*, *fileList: List[str]*) → List[str]

Class-private funtion to filter a list of files to include only allowed ones. Args: fileList - list of files to filter Returns: filtered fileList - containing only the allowed files

`rtCommon.dataInterface.uploadFilesFromList`(*dataInterface*, *fileList: List[str]*, *outputDir: str*, *srcDirPrefix=None*) → None

Copies files in fileList from the remote onto the system where this call is being made.

`rtCommon.dataInterface.downloadFilesFromList`(*dataInterface*, *fileList: List[str]*, *outputDir: str*, *srcDirPrefix=None*) → None

Copies files in fileList from this computer to the remote.

`rtCommon.dataInterface.uploadFolderToCloud`(*dataInterface*, *srcDir: str*, *outputDir: str*) → None

Copies a folder (directory) from the remote to the system where this call is run

`rtCommon.dataInterface.uploadFilesToCloud`(*dataInterface*, *srcFilePattern: str*, *outputDir: str*)

Copies files matching (regex) srcFilePattern from the remote onto the system

where this call is being made.

`rtCommon.dataInterface.downloadFolderFromCloud`(*dataInterface*, *srcDir: str*, *outputDir: str*, *deleteAfter=False*) → None

Copies a directory from the system where this call is made to the remote system.

`rtCommon.dataInterface.downloadFilesFromCloud`(*dataInterface*, *srcFilePattern: str*, *outputDir: str*, *deleteAfter=False*) → None

Copies files matching srcFilePattern from the system where this call is made

to the remote system.

8.1.1.11 `rtCommon.dicomToBidsService`

---

dicomToBidsService.py

A very basic DICOM to BIDS-I converter.

Module Contents

Functions

dicomToBidsInc(dicomImg: pydicom.dataset.Dataset, extraMetadata: dict = {}) → rtCommon.bidsIncremental.BidsIncremental	

`rtCommon.dicomToBidsService.`**`dicomToBidsInc`**(*dicomImg: pydicom.dataset.Dataset*, *extraMetadata: dict = {}*) → *rtCommon.bidsIncremental.BidsIncremental*

8.1.1.12 `rtCommon.errors`

Excpetion definitions for rtfMRI

Module Contents

exception `rtCommon.errors.`**`RTError`**

Bases: `Exception`

Top level general error

exception `rtCommon.errors.`**`ValidationError`**

Bases: *RTError*

Invalid information supplied in a call

exception `rtCommon.errors.`**`StateError`**

Bases: *RTError*

System is not in a valid state relative to the request

exception `rtCommon.errors.`**`RequestError`**

Bases: *RTError*

Error in the request

exception `rtCommon.errors.`**`MessageError`**

Bases: *RTError*

Invalid message

exception rtCommon.errors.**InvocationError**

Bases: *RTError*

program arguments incorrect

exception rtCommon.errors.**VersionError**

Bases: *RTError*

Client/Server code versions don't agree

exception rtCommon.errors.**MissedDeadlineError**

Bases: *RTError*

Server missed a deadline

exception rtCommon.errors.**MissedMultipleDeadlines**

Bases: *RTError*

Server missed two or more deadlines

exception rtCommon.errors.**NotImplementedError**

Bases: *RTError*

Functionality is not implemented yet

exception rtCommon.errors.**MissingMetadataError**

Bases: *RTError*

Required BIDS metadata missing

exception rtCommon.errors.**MetadataMismatchError**

Bases: *RTError*

Mismatch in metadata (e.g., BIDS or NIfTI)

exception rtCommon.errors.**DimensionError**

Bases: *RTError*

Invalid image dimensions for requested operation

exception rtCommon.errors.**QueryError**

Bases: *RTError*

A query failed or returned unexpected results

8.1.1.13 rtCommon.exampleInterface

An example remote interface. Copy this file as a starting point for a new service.

Remote interfaces can be easily created by subclassing the RemoteExtensible class.

All methods in the subclass will be callable through an RPC interface which the experiment script, running in the cloud, can access through the client object.

In addition to creating a subclassed RemoteExtensible, this class (object) must be instantiated within the projectServer-RPC class, e.g. exposed_ExampleInterface. The instantiated object is what will be invoked when RPC calls are made to the exampleInterface.

For the remote case, there must be a remote end-point to handle the request. This can be within a service (such as scannerDataService) that instantiates the classes (such as dataInterface, bidsInterface, exampleInterface etc.) that will handle the remote forwarded requests. Add the object to a data service, or create a new one, that will run at the control room computer and is initialized with dataRemote=False.

The control room instance will be the actual instance and the projectServerRPC instance is a stub instance (dataRemote=True) that forwards request to the control room instance.

Module Contents

Classes

ExampleInterface	Provides functions for experimenter scripts

class rtCommon.exampleInterface.**ExampleInterface**(*dataRemote=False*)

Bases: *rtCommon.remoteable.RemoteableExtensible*

Provides functions for experimenter scripts

echo(*self*, *val*)

testMethod(*self*, **args*, ***kwargs*)

8.1.1.14 rtCommon.exampleService

An example remote command-line service, for example as would be run at the scanner computer or the presentation computer to receive requests from the the classification script.

This service instantiates an ExampleInterface for sending/receiving example requests to the projectServer in the cloud. It connects to the remote projectServer. Once a connection is established it waits for requests and invokes the ExampleInterface functions to handle them.

Module Contents

Classes

ExampleService

Attributes

currPath
rootPath
connectionArgs

rtCommon.exampleService.**currPath**

rtCommon.exampleService.**rootPath**

class rtCommon.exampleService.**ExampleService**(*args*, *webSocketChannelName='wsData'*)

runDetached(*self*)

Starts the receiver in its own thread.

rtCommon.exampleService.**connectionArgs**

8.1.1.15 rtCommon.fileWatcher

FileWatcher implements a class that watches for files to be created in a directory and then returns the notification that the files is now available.

The FileWatcher class is a virtual class of sorts with two underlying implementations, one for Mac and Windows (WatchdogFileWatcher) and one for Linux (InotifyFileWatcher).

Module Contents

Classes

FileWatcher	Virtual class to watch for the arrival of new files and notify.
WatchdogFileWatcher	Version of FileWatcher for Mac and Windows using Watchdog toolkit.
FileNotifyHandler	Handler class that will receive the watchdog notifications. It will queue the notifications
InotifyFileWatcher	Version of FileWatcher for Linux using Inotify interface.

class rtCommon.fileWatcher.**FileWatcher**

Virtual class to watch for the arrival of new files and notify.

__del__(*self*)

initFileNotifier(*self*, *dir*, *filePattern*, *minFileSize*, *demoStep=0*)

waitForFile(*self*, *filename*, *timeout=0*, *timeCheckIncrement=1*)

class rtCommon.fileWatcher.**WatchdogFileWatcher**

Version of FileWatcher for Mac and Windows using Watchdog toolkit.

__del__(*self*)

initFileNotifier(*self*, *dir: str*, *filePattern: str*, *minFileSize: int*, *demoStep: int = 0*) → None

Initialize the file watcher to watch in the specified directory for the specified regex-based filepattern.

Parameters

- **dir** (*str*) – Directory to watch in
- **filePattern** (*str*) – Regex-based filepattern to watch for
- **minFileSize** (*int*) – Minimum file size necessary to consider the file is wholely written. Below this size the filewatcher will assume file is paritally written and continue to wait.
- **demoStep** (*int*) – If non-zero then it will space out file notifications by demoStep seconds. This is used when the image files are pre-existing but we want to simulate as if the arrive from the scanner every few seconds (demoStep seconds).

waitForFile(*self*, *filename: str*, *timeout: int = 0*, *timeCheckIncrement: int = 1*) → Optional[str]

Wait for a specific filename to be created in the directory specified in initFileNotifier.

Parameters

- **filename** – Name of File to watch for creation of. If filename includes a path it must match that specified in initFileNotifier.
- **timeout** – Max number of seconds to watch for the file creation. If timeout expires before the file is created then None will be returned
- **timeCheckIncrement** – Time interval (secs) to check if file exists in case file creation events are somehow missed.

Returns

The filename of the created file (same as input arg) or None if timeout expires

class rtCommon.fileWatcher.**FileNotifyHandler**(*q*, *patterns*)

Bases: `watchdog.events.PatternMatchingEventHandler`

Handler class that will receive the watchdog notifications. It will queue the notifications int the queue provided during to the init function.

on_created(*self*, *event*)

on_modified(*self*, *event*)

class rtCommon.fileWatcher.**InotifyFileWatcher**

Version of FileWatcher for Linux using Inotify interface.

__del__(*self*)

initFileNotifier(*self*, *dir: str*, *filePattern: str*, *minFileSize: int*, *demoStep: int = 0*) → None

Initialize the file watcher to watch for files in the specified directory. Note: inotify doesn't use filepatterns

Parameters

- **dir** (*str*) – Directory to watch in
- **filePattern** (*str*) – ignored by inotify implementation
- **minFileSize** (*int*) – Minimum file size necessary to consider the file is wholely written. Below this size the filewatcher will assume file is paritally written and continue to wait.
- **demoStep** (*int*) – If non-zero then it will space out file notifications by demoStep seconds. This is used when the image files are pre-existing but we want to simulate as if the arrive from the scanner every few seconds (demoStep seconds).

waitForFile(*self*, *filename: str*, *timeout: int = 0*, *timeCheckIncrement: int = 1*) → Optional[str]

Wait for a specific filename to be created in the directory specified in initFileNotifier.

Parameters

- **filename** – Name of File to watch for creation of. If filename includes a path it must match that specified in initFileNotifier.
- **timeout** – Max number of seconds to watch for the file creation. If timeout expires before the file is created then None will be returned
- **timeCheckIncrement** – Time interval (secs) to check if file exists in case file creation events are somehow missed.

Returns

The filename of the created file (same as input arg) or None if timeout expires

notifyEventLoop(*self*)

Thread function which gets notifications and queues them in the fileNotifyQ

8.1.1.16 rtCommon.imageHandling

This script includes all of the functions that are needed (1) to transfer dicom files back and forth from the cloud and (2) to convert the dicom files to nifti files, which is a file format that is better for data analyses.

Module Contents

Functions

getDicomFileName(cfg, scanNum, fileNum)	This function takes in different variables (which are both specific to the specific
anonymizeDicom(dicomImg)	This function takes in the dicom image that you read in and deletes
readDicomFromFile(filename)	This function takes the path/name of the dicom file of interest and reads it.
writeDicomFile(dicomImg, filename)	This function takes a dicomImg and the path/name of the file to write to.
writeDicomToBuffer(dicomImg)	This function write dicom data to binary mode so that it can be transferred
readDicomFromBuffer(data) → pydicom.dataset.FileDataset	This function reads data that is in binary mode and then converts it into a
readRetryDicomFromDataInterface(dataInterface, filename, timeout=5)	This function is waiting and watching for a dicom file to be sent to the cloud
parseDicomVolume(dicomImg, sliceDim)	The raw dicom file coming from the scanner will be a 2-dimensional picture
getDicomAcquisitionTime(dicomImg) → datetime.datetime.time	Returns the acquisition time as a datetime.time
getDicomRepetitionTime(dicomImg) → float	Returns the TR repetition time in seconds
dicomTimeToNextTr(dicomImg, clockSkew, now=None)	Based on Dicom header. Returns seconds to next TR start
bidsIncrementalTimeToNextTr(bidsIncremental, clockSkew, now=None)	Based on BidsIncremental header. Returns seconds to next TR start
getAxesForTransform(startingDicomFile, cfg)	This function takes a single dicom file (which can be the first file) and
getTransform(target_orientation, dicom_orientation)	This function calculates the right transformation needed to go from the original
saveAsNiftiImage(dicomDataObject, fullNiftiFilename, cfg, reference)	This function takes in a dicom data object written in bytes, what you expect
convertDicomFileToNifti(dicomFilename, niftiFilename)	
niftiToMem(niftiImg)	Fully load Nifti image into memory and remove any file-backing.
readNifti(niftiFilename, memCached=True)	
convertDicomImgToNifti(dicomImg, dicomFilename=None)	Given an in-memory dicomImg, convert it to an in-memory niftiImg.

Attributes

binPath
attributesToAnonymize

rtCommon.imageHandling.**binPath**

rtCommon.imageHandling.**getDicomFileName**(*cfg*, *scanNum*, *fileNum*)

This function takes in different variables (which are both specific to the specific scan and the general setup for the entire experiment) to produce the full filename for the dicom file of interest.

Used externally.

rtCommon.imageHandling.**attributesToAnonymize = ['PatientID', 'PatientAge', 'PatientBirthDate', 'PatientName', 'PatientSex', 'PatientSize',...**

rtCommon.imageHandling.**anonymizeDicom**(*dicomImg*)

This function takes in the dicom image that you read in and deletes lots of different attributes. The purpose of this is to anonymize the dicom data before transferring it to the cloud.

Used externally.

rtCommon.imageHandling.**readDicomFromFile**(*filename*)

This function takes the path/name of the dicom file of interest and reads it.

Used internally.

rtCommon.imageHandling.**writeDicomFile**(*dicomImg*, *filename*)

This function takes a dicomImg and the path/name of the file to write to.

Used internally.

rtCommon.imageHandling.**writeDicomToBuffer**(*dicomImg*)

This function write dicom data to binary mode so that it can be transferred to the cloud, where it again becomes a dicom. This is needed because files are transferred to the cloud in the following manner: dicom from scanner –> binary file –> transfer to cloud –> dicom file

Used internally.

rtCommon.imageHandling.**readDicomFromBuffer**(*data*) → pydicom.dataset.FileDataset

This function reads data that is in binary mode and then converts it into a structure that can be read as a dicom file. This is necessary because files are transferred to the cloud in the following manner: dicom from scanner –> binary file –> transfer to cloud –> dicom file

Use internally.

rtCommon.imageHandling.**readRetryDicomFromDataInterface**(*dataInterface*, *filename*, *timeout=5*)

This function is waiting and watching for a dicom file to be sent to the cloud from the scanner. It dodes this by calling the 'watchFile()' function in the 'dataInterface.py'

Used externally (and internally). :param dataInterface: A dataInterface to make calls on :param filename: Dicom filename to watch for and read when available :param timeout: Max number of seconds to wait for file to be available

Returns
The dicom image

`rtCommon.imageHandling.`**`parseDicomVolume`**(*dicomImg*, *sliceDim*)

The raw dicom file coming from the scanner will be a 2-dimensional picture made of up multiple image slices that are tiled together. This function separates the image slices to form a single volume.

Used externally.

`rtCommon.imageHandling.`**`getDicomAcquisitionTime`**(*dicomImg*) → datetime.datetime.time

Returns the acquisition time as a datetime.time Note: day, month and year are not specified

`rtCommon.imageHandling.`**`getDicomRepetitionTime`**(*dicomImg*) → float

Returns the TR repetition time in seconds

`rtCommon.imageHandling.`**`dicomTimeToNextTr`**(*dicomImg*, *clockSkew*, *now=None*)

Based on Dicom header. Returns seconds to next TR start

`rtCommon.imageHandling.`**`bidsIncrementalTimeToNextTr`**(*bidsIncremental*, *clockSkew*, *now=None*)

Based on BidsIncremental header. Returns seconds to next TR start

`rtCommon.imageHandling.`**`getAxesForTransform`**(*startingDicomFile*, *cfg*)

This function takes a single dicom file (which can be the first file) and the config file to obtain the target_orientation (in nifti space) and the dicom_orientation (in the original space).

NOTE: You only need to run this function once to obtain the target and dicom orientations. You can save and load these variables so that 'getTransform()' is hard coded.

Used externally.

`rtCommon.imageHandling.`**`getTransform`**(*target_orientation*, *dicom_orientation*)

This function calculates the right transformation needed to go from the original axis space (dicom_orientation) to the target axis space in nifti space (target_orientation).

Used externally.

`rtCommon.imageHandling.`**`saveAsNiftiImage`**(*dicomDataObject*, *fullNiftiFilename*, *cfg*, *reference*)

This function takes in a dicom data object written in bytes, what you expect the dicom file to be called (we will use the same name format for the nifti file), and the config file while will have (1) the axes transformation for the dicom file and (2) the header information from a reference scan.

Used externally.

`rtCommon.imageHandling.`**`convertDicomFileToNifti`**(*dicomFilename*, *niftiFilename*)

`rtCommon.imageHandling.`**`niftiToMem`**(*niftiImg*)

Fully load Nifti image into memory and remove any file-backing. NiftiImage by default contains a pointer to the image file for the data.

`rtCommon.imageHandling.`**`readNifti`**(*niftiFilename*, *memCached=True*)

`rtCommon.imageHandling.`**`convertDicomImgToNifti`**(*dicomImg*, *dicomFilename=None*)

Given an in-memory dicomImg, convert it to an in-memory niftiImg. Note: due to how nibabel niftiImage works, it is just a pointer to a file on disk, so we can't delete the niftiFile while niftiImage is in use.

8.1.1.17 `rtCommon.openNeuro`

An interface to access OpenNeuro data and metadata. It can download and cache OpenNeuro data for playback.

Module Contents

Classes

OpenNeuroCache

class `rtCommon.openNeuro.`**`OpenNeuroCache`**(*cachePath='/tmp/openneuro/'*)

`getCachePath`(*self*)

`getS3Client`(*self*)

Returns an s3 client in order to reuse the same s3 client without always creating a new one. Not thread safe currently.

`getDatasetList`(*self*, *refresh=False*)

Returns a list of all datasets available in OpenNeuro S3 storage. See https://openneuro.org/public/datasets for datasets info. Alternate method to access from a command line call: [aws s3 –no-sign-request ls s3://openneuro.org/]

`isValidAccessionNumber`(*self*, *dsAccessionNum*)

`getSubjectList`(*self*, *dsAccessionNum*)

Returns a list of all the subjects in a dataset

Parameters
`dsAccessionNum` – accession number of dataset to lookup

Returns
list of subjects in that dataset

`getDescription`(*self*, *dsAccessionNum*)

Returns the dataset description file as a python dictionary

`getReadme`(*self*, *dsAccessionNum*)

Return the contents of the dataset README file. Downloads toplevel dataset files if needed.

`getArchivePath`(*self*, *dsAccessionNum*)

Returns the directory path to the cached dataset files

`downloadData`(*self*, *dsAccessionNum*, *downloadWholeDataset=False*, ***entities*)

This command will sync the specified portion of the dataset to the cache directory. Note: if only the accessionNum is supplied then it will just sync the top-level files. Sync doesn't re-download files that are already present in the directory. Consider using –delete which removes local cache files no longer on the remote.

Parameters

- `dsAccessionNum` – accession number of the dataset to download data for.
- `downloadWholeDataset` – boolean, if true all files in the dataset will be downloaded.

- **entities** – BIDS entities (subject, session, task, run, suffix) that define the particular subject/run of the data to download.

Returns
Path to the directory containing the downloaded dataset data.

8.1.1.18 rtCommon.openNeuroService

A command-line service to be run where the OpenNeuro data is downloaded and cached. This service instantiates a BidsInterface object for serving the data back to the client running in the cloud. It connects to the remote projectServer. Once a connection is established it waits for requets and invokes the BidsInterface functions to handle them.

Module Contents

Classes

OpenNeuroService	A class that implements the OpenNeuroService by instantiating a BidsInterface, connecting

Attributes

currPath
rootPath
connectionArgs

rtCommon.openNeuroService.**currPath**

rtCommon.openNeuroService.**rootPath**

class rtCommon.openNeuroService.**OpenNeuroService**(*args*, *webSocketChannelName='wsData'*)

A class that implements the OpenNeuroService by instantiating a BidsInterface, connecting to the remote projectServer and servicing requests to the BidsInterface.

runDetached(*self*)

Starts the receiver in it's own thread.

rtCommon.openNeuroService.**connectionArgs**

8.1.1.19 `rtCommon.projectServer`

Main (command-line) program for running the projectServer. Instantiates both the web interface and an RPC server for handling client script commnds.

Module Contents

Classes

ProjectServer	The main server for running a project. This server starts both the web server and an RPC server.

Attributes

currPath
rootPath
argParser

`rtCommon.projectServer.`**`currPath`**

`rtCommon.projectServer.`**`rootPath`**

`class` `rtCommon.projectServer.`**`ProjectServer`**(*args*)

The main server for running a project. This server starts both the web server and an RPC server.

`start`(*self*)

Start the Web and RPC servers. This function doesn't return.

`stop`(*self*)

`rtCommon.projectServer.`**`argParser`**

8.1.1.20 `rtCommon.projectServerRPC`

This module provides the RPC server that provides communication services to the experiment script. Note: When using services local to the projectServer, RPCs call do one hop, client –> rpyc server (method) When using remote services RPC calls traverse two links, client –> rpyc server –> (via websockets) remote service

Module Contents

Classes

ProjectRPCService	Provides Remote Procedure Call service for the experimenter's script. This service runs
RPCHandlers	Class for websocket RPC handlers. This class handles the second hop described in

Functions

startRPCThread(rpcService, hostname=None, port=12345)	This function starts the Project RPC server for communication between

class rtCommon.projectServerRPC.**ProjectRPCService**(*dataRemote=False*, *subjectRemote=False*, *webUI=None*)

Bases: rpyc.Service

Provides Remote Procedure Call service for the experimenter's script. This service runs in the projectServer to receive and handle RPC requests from the experimenter script. It makes available to the client a DataInterface, SubjectInterface and WebInterface.

exposed_DataInterface

exposed_SubjectInterface

exposed_BidsInterface

exposed_WebDisplayInterface

exposed_ExampleInterface

exposed_isDataRemote(*self*)

exposed_isSubjectRemote(*self*)

static registerDataCommFunction(*commFunction*)

Register the function call to forward an RPC data requests over websockets. This is the communication for the second hop (described above) to the remote service.

static registerSubjectCommFunction(*commFunction*)

Register the function call to forward an RPC subject requests over websockets. This is the communication for the second hop (described above) to the remote service.

on_connect(*self*, *conn*)

on_disconnect(*self*, *conn*)

rtCommon.projectServerRPC.**startRPCThread**(*rpcService*, *hostname=None*, *port=12345*)

This function starts the Project RPC server for communication between the projectServer and the experiment script. IT DOES NOT RETURN.

class `rtCommon.projectServerRPC.`**`RPCHandlers`**(*ioLoopInst*, *webDisplayInterface*)

Class for websocket RPC handlers. This class handles the second hop described in note below, namely from rpyc server to the remote service via websockets.

Note: When using local services, RPC call do one hop, client –> rypc server object/method When using remote services RPC calls traverse two links, client –> rpyc server –> (via websockets) remote service

`dataWsCallback`(*self*, *client*, *message*)

Callback for requests sent to remote service over the wsData channel

`subjectWsCallback`(*self*, *client*, *message*)

Callback for requests sent to remote service over the wsSubject channel

`dataRequest`(*self*, *cmd*, *timeout=60*)

Function to initiate an outgoing data request from the RPC server to a remote service

`subjectRequest`(*self*, *cmd*, *timeout=60*)

Function to initiate an outgoing subject request from the RPC server to a remote service

`close_pending_requests`(*self*, *channelName*)

Close out all pending RPC requests when a connection is disconnected

`setError`(*self*, *errStr*)

Set an error messsage in the user's browser window

`handleRPCRequest`(*self*, *channelName*, *cmd*, *timeout=60*)

Process RPC requests using websocket RequestHandler to send the request

8.1.1.21 `rtCommon.projectUtils`

This module contains utility functions used internally by the rtcloud services

Module Contents

Functions

`watchForExit`()	Create a thread which will detect if the parent process exited by
`processShouldExitThread`()	If this client was spawned by a parent process, then by listening on
`formatFileData`(filename, data)	Convert raw bytes to a specific memory format such as dicom or matlab data
`login`(serverAddr, username, password, testMode=False)	Logs in to a web service, prompting user for username/password as needed,
`checkSSLCertAltName`(certFilename, altName)	Check if altName is list as an alternate server name in the ssl certificate
`makeSSLCertFile`(serverName)	

`rtCommon.projectUtils.`**`watchForExit`**()

Create a thread which will detect if the parent process exited by reading from stdin, when stdin is closed exit this process.

rtCommon.projectUtils.**processShouldExitThread**()

If this client was spawned by a parent process, then by listening on stdin we can tell that the parent process exited when stdin is closed. When stdin is closed we can exit this process as well.

rtCommon.projectUtils.**formatFileData**(*filename*, *data*)

Convert raw bytes to a specific memory format such as dicom or matlab data

rtCommon.projectUtils.**login**(*serverAddr*, *username*, *password*, *testMode=False*)

Logs in to a web service, prompting user for username/password as needed, and returns a session_cookie to allow future requests without logging in.

rtCommon.projectUtils.**checkSSLCertAltName**(*certFilename*, *altName*)

Check if altName is list as an alternate server name in the ssl certificate

rtCommon.projectUtils.**makeSSLCertFile**(*serverName*)

8.1.1.22 rtCommon.remoteable

A set of classes that can be subclassed or extended to allow for automatically forwarding methods calls on the subclass to a remote RPC handler.

On cloud side we will have a remoteInstance (with remoteCall stub) that calls the networking crossbar to send the request to the remote. On the remote side we will have a RemoteHandler instance and when messages are received will dispatch them to the handler.

Module Contents

Classes

Remoteable	A class that can be subclassed to allow remote invocation.
RemoteStub	A remote stub class where none of the attributes of the original class are defined.
RemoteableExtensible	A class that can be subclassed to allow remote invocation. The remote and local versions
RemoteHandler	Class that runs at the remote and as message requests are received they are dispatched

Attributes

defaultRpcTimeout

rtCommon.remoteable.**defaultRpcTimeout** = 60

class rtCommon.remoteable.**Remoteable**(*isRemote=False*)

Bases: object

A class that can be subclassed to allow remote invocation. When isRemote is True it returns a remote stub instance, when false it returns the real instance

class rtCommon.remoteable.**RemoteStub**(*classType*, *isRemote=True*)

Bases: object

A remote stub class where none of the attributes of the original class are defined. Therefore __getattr__ will be called for all attributes (i.e. intercepting normal calls) and this class overrides __getattr__ to forward the call request to a remote instance via the registered communication channel function.

setRPCTimeout(*self*, *timeout*)

registerCommFunction(*self*, *commFunction*)

remoteCall(*self*, *attribute*, **args*, ***kwargs*) → any

__getattr__(*self*, *name*)

class rtCommon.remoteable.**RemoteableExtensible**(*isRemote=False*)

Bases: object

A class that can be subclassed to allow remote invocation. The remote and local versions are the same class type (not a stub) and in the remote instance case attributes can be registerd as 'local' meaning calls to them will be handled local, all other calls would be sent to the remote instance.

isRunningRemote(*self*)

setRPCTimeout(*self*, *timeout*)

registerCommFunction(*self*, *commFunction*)

remoteCall(*self*, *attribute*, **args*, ***kwargs*) → any

addLocalAttributes(*self*, *methods*)

__getattribute__(*self*, *name*)

Return getattr(self, name).

class rtCommon.remoteable.**RemoteHandler**

Class that runs at the remote and as message requests are received they are dispatched to this class for processing.

registerClassInstance(*self*, *classType*, *classInstance*)

registerClassNameInstance(*self*, *className*, *classInstance*)

runRemoteCall(*self*, *callDict*)

8.1.1.23 rtCommon.resample

Module Contents

rtCommon.resample.**image_to_resample**

rtCommon.resample.**image_reference**

rtCommon.resample.**resampled_image**

rtCommon.resample.**base_name**

8.1.1.24 `rtCommon.scannerDataService`

A command-line service to be run where the scanner data is generated (i.e. the control room). This service instantiates a DataInterface and BidsInterface object for serving the data back to the client running in the cloud. It connects to the remote projectServer. Once a connection is established it waits for requets and invokes the DataInterface or BidsInterface functions to handle them.

Module Contents

Classes

ScannerDataService

Attributes

currPath
rootPath
defaultAllowedDirs
defaultAllowedTypes
connectionArgs

rtCommon.scannerDataService.**currPath**

rtCommon.scannerDataService.**rootPath**

rtCommon.scannerDataService.**defaultAllowedDirs = ['/tmp', '/data']**

rtCommon.scannerDataService.**defaultAllowedTypes = ['.dcm', '.mat', '.txt']**

class rtCommon.scannerDataService.**ScannerDataService**(*args*, *webSocketChannelName='wsData'*)

rtCommon.scannerDataService.**connectionArgs**

8.1.1.25 `rtCommon.serialization`

Module Contents

Functions

`encodeByteTypeArgs`(cmd) → dict	Check if any args are of type 'bytes' and if so base64 encode them.
`decodeByteTypeArgs`(cmd) → dict	Decodes rpc args that were previously encoded with encodeByteTypeArgs.
`npToPy`(data)	Converts components in data that are numpy types to regular python types.
`encodeMessageData`(message, data, compress)	b64 encode binary data in preparation for sending. Updates the message header
`decodeMessageData`(message)	Given a message encoded with encodeMessageData (above), decode that message.
`generateDataParts`(data, msg, compress)	A python "generator" that, for data > 10 MB, will create multi-part
`unpackDataMessage`(msg)	Handles receiving multipart (an singlepart) data messages and returns the data bytes.

Attributes

`multiPartDataCache`
`dataPartSize`

rtCommon.serialization.**multiPartDataCache**

rtCommon.serialization.**dataPartSize**

rtCommon.serialization.**encodeByteTypeArgs**(*cmd*) → dict

Check if any args are of type 'bytes' and if so base64 encode them. The original arg will be replaced with a tag that will reference the encoded bytes within the cmd dict. :param cmd: a dictionary of the command to check

Returns
A cmd dictionary with the byte args encoded

rtCommon.serialization.**decodeByteTypeArgs**(*cmd*) → dict

Decodes rpc args that were previously encoded with encodeByteTypeArgs. :param cmd: a dictionary with encoded args

Returns
a dictionary with decoded args

Return type
cmd

rtCommon.serialization.**npToPy**(*data*)

Converts components in data that are numpy types to regular python types. Uses recursive calls to convert nested data structures :returns: The data structure with numpy elements converted to python types

rtCommon.serialization.**encodeMessageData**(*message*, *data*, *compress*)

b64 encode binary data in preparation for sending. Updates the message header as needed :param message: message header :type message: dict :param data: binary data :type data: bytes :param compress: whether to compress binary data :type compress: bool

Returns
Modified message dict with appropriate fields filled in

rtCommon.serialization.**decodeMessageData**(*message*)

Given a message encoded with encodeMessageData (above), decode that message. Validate and retrive orignal bytes. :param message: encoded message to decode :type message: dict

Returns
The byte data of the original message from the sender

rtCommon.serialization.**generateDataParts**(*data*, *msg*, *compress*)

A python "generator" that, for data > 10 MB, will create multi-part messages of 10MB each to send the data incrementally :param data: data to send :type data: bytes :param msg: message header for the request :type msg: dict :param compress: whether to compress the data befor sending :type compress: bool

Returns

Repeated calls return the next partial message to be sent until
None is returned

rtCommon.serialization.**unpackDataMessage**(*msg*)

Handles receiving multipart (an singlepart) data messages and returns the data bytes. In the case of multipart messages a data cache is used to store intermediate parts until all parts are received and the final data can be reconstructed. :param msg: Potentially on part of a multipart message to unpack :type msg: dict

Returns
None if not all multipart messages have been received yet, or Data bytes if all multipart messages have been received.

8.1.1.26 rtCommon.structDict

StructDictClass - contains classes StructDict and MatlabStructDict to make it
possible to access a dictionary with syntax struct.field.

Module Contents

Classes

StructDict	Class that adds a structure type syntax to dictionaries,
MatlabStructDict	Subclass dictionary so that elements can be accessed either as dict['key']

Functions

copy_toplevel(data)	
recurseCreateStructDict(data)	Given a recursive dictionary, i.e. a dictionary that has
recurseSDtoDict(data)	Given a recursive StructDict, i.e. that has child StructDicts
convertStructuredArrayToDict(sArray)	Convert a NumPy structured array to a dictionary.
isStructuredArray(var) → bool	Return True if var is a numpy structured array

Attributes

structDictType

class rtCommon.structDict.**StructDict**

Bases: dict

Class that adds a structure type syntax to dictionaries, i.e. 'dict.field' will invoke dict['field']

__getattr__(*self*, *key*)

Implement getattr to support syntax "data.field"

__setattr__(*self*, *key*, *val*)

Implement setattr to support syntax "data.field=x"

__delattr__(*self*, *key*)

Implement delattr to support syntax "del data.field"

__getstate__(*self*)

Needed for pickling, return the underlying dictionary

__setstate__(*self*, *dict_entries*)

Needed for pickling, set the underlying dictionary

copy(*self*)

D.copy() -> a shallow copy of D

rtCommon.structDict.**copy_toplevel**(*data*)

rtCommon.structDict.**recurseCreateStructDict**(*data*)

Given a recursive dictionary, i.e. a dictionary that has child dictionaries or lists of dictionaries, convert each child dictionary to a StructDict.

rtCommon.structDict.**structDictType**

rtCommon.structDict.**recurseSDtoDict**(*data*)

Given a recursive StructDict, i.e. that has child StructDicts or lists of StructDict, convert each child StructDict to a Dictionary.

class rtCommon.structDict.**MatlabStructDict**(*dictionary*, *name=None*)

Bases: *StructDict*

Subclass dictionary so that elements can be accessed either as dict['key'] of dict.key. If elements are of type NumPy structured arrays, convert them to dictionaries and then to MatlabStructDict also.

__getattr__(*self*, *key*)

Implement getattr to support syntax x=data.field

__setattr__(*self*, *key*, *val*)

Implement setattr to support syntax data.field=x

copy(*self*)

D.copy() -> a shallow copy of D

fields(*self*)

list all fields including subfields of the special 'name' field `rtCommon.structDict.convertStructuredArrayToDict(sArray)`

Convert a NumPy structured array to a dictionary.

`rtCommon.structDict.isStructuredArray(var)` → bool

Return True if var is a numpy structured array

8.1.1.27 rtCommon.subjectInterface

SubjectInterface is a client interface (i.e. for the experiment script running in the cloud) that facilitates interaction with the subject in the MRI scanner, such as sending classification results to drive the subject display, or receiving their responses (e.g. button-box).

To support RPC calls from the client, there will be two instances of SubjectInterface, one at the cloud projectServer which is a stub to forward requests (started with subjectRemote=True), and another at the presentation computer, run as a service and with subjectRemote=False.

The subjectInterface instance can also be instantiated within the projectServer if the projectServer and presentation computer run on the same system.

Module Contents

Classes

SubjectInterface	Provides functions for sending feedback and receiving reponses from the subject in the scanner.

class `rtCommon.subjectInterface.SubjectInterface(subjectRemote=False)`

Bases: *rtCommon.remoteable.RemoteableExtensible*

Provides functions for sending feedback and receiving reponses from the subject in the scanner.

If subjectRemote=True, then the RemoteExtensible parent class takes over and forwards all requests to a remote server via a callback function registered with the RemoteExtensible object. In that case *none* of the methods below will be locally invoked.

If subjectRemote=False, then the methods below will be invoked locally and the RemoteExtensible parent class is inoperable (i.e. does nothing).

When classification results are received from the experiment script they are placed in a queue which the presentation script can then access. The presentation script can wait on the queue for new results to arrive.

`setResult(self, runId: int, trId: int, value: float, onsetTimeDelayMs: int = 0)` → None

When setResult is called by the experiment script it queues the result for the presentation script to later read and use to provide subject feedback. :param runId: experiment specific identifier of the run :param trId: volume number of the dicom within a run :param value: the classification result from processing the dicom image for this TR :param onsetTimeDelayMs: time in milliseconds to wait before presenting the feedback stimulus

`setResultDict(self, values: dict, onsetTimeDelayMs: int = 0)` → None

Same as setResult except the caller can provide a dictionary with whatever entries are desired to be used at the subjectService. :param values: a dictionary with the desired values to send for this TR :param onsetTimeDelayMs: time in milliseconds to wait before presenting the feedback stimulus

setMessage(*self*, *message: str*) → None

Updates the message displayed to the subject

getResponse(*self*, *runId: int*, *trId: int*)

Retrieve the subject response, used by the classification script. See *note* above - these local versions of the function are just for testing or as a place holder when no external subjectInterface is used.

getAllResponses(*self*)

Retrieve all subject responses since the last time this call was made

dequeueResult(*self*, *block: bool = False*, *timeout: int = None*) → float

Return the next result value sent by the experiment script. Used by the presentation script. See *note* above - these local versions of the function are just for testing or as a place holder when no external version is used.

8.1.1.28 `rtCommon.subjectService`

An example command-line service to be run at the presentation computer to receive classification results from the classification script.

This service instantiates a SubjectInterface for serving sending/receiving subject feedback to the projectServer in the cloud. It connects to the remote projectServer. Once a connection is established it waits for requets and invokes the SubjecInterface functions to handle them.

Note: This service is intended as an example. In practice this subjectInterface would likely be instantiated within the presentation script and there it would use WsRemoteService to connect this instance to the remote projectServer where the classification is script running.

Module Contents

Classes

SubjectService

Attributes

currPath
rootPath
connectionArgs

`rtCommon.subjectService.`**currPath**

`rtCommon.subjectService.`**rootPath**

class `rtCommon.subjectService.`**SubjectService**(*args*, *webSocketChannelName='wsSubject'*)

runDetached(*self*)

Starts the receiver in it's own thread.

rtCommon.subjectService.**connectionArgs**

8.1.1.29 rtCommon.utils

Utils - various utilites for rtfMRI

Module Contents

Classes

DebugLevels

Functions

`parseMatlabStruct`(top_struct) → rtCommon.structDict.MatlabStructDict	Load matlab data file and convert it to a MatlabStructDict object for
`loadMatFile`(filename: str) → rtCommon.structDict.MatlabStructDict	
`loadMatFileFromBuffer`(data) → rtCommon.structDict.MatlabStructDict	
`find`(A: numpy.ndarray) → numpy.ndarray	Find nonzero elements of A in flat "C" row-major indexing order
`loadConfigFile`(filename)	
`flatten_1Ds`(M)	
`dateStr30`(timeval)	
`md5SumFile`(filePath)	
`findNewestFile`(filepath, filepattern)	Find newest file matching pattern according to filesystem creation time.
`copyFileWildcard`(src, dst)	
`fileCount`(dir, pattern)	
`writeFile`(filename, data, binary=True)	
`readFile`(filename, binary=True)	
`deleteFilesFromList`(fileList)	
`deleteFolder`(dir)	
`deleteFolderFiles`(dir, recursive=True)	
`runCmdCheckOutput`(cmd, outputRegex)	
`demoDelay`(demoStep, prevEventTime=None)	Provides a delay of demoStep seconds from the previous event time (i.e. sleeps)
`installLoggers`(consoleLevel, fileLevel, filename=None)	
`getGitCodeId`()	
`stringPartialFormat`(text, tag, val) → str	
`trimDictBytes`(msg, trimSize=64)	
`getTimeToNextTR`(lastTrTime, trRepSec, nowTime, clockSkew) → float	Returns seconds to next TR start time
`dtimeToSeconds`(valTime) → float	Given a datetime.time return seconds.fraction since day beginning
`calcAvgRoundTripTime`(pingFunc)	Returns average round trip time in seconds

Attributes

gitCodeId

`rtCommon.utils.parseMatlabStruct`(*top_struct*) → *rtCommon.structDict.MatlabStructDict*

Load matlab data file and convert it to a MatlabStructDict object for easier python access. Expect only one substructure array, and use that one as the name variable in MatlabStructDict. Return the MatlabStructDict object

`rtCommon.utils.loadMatFile`(*filename: str*) → *rtCommon.structDict.MatlabStructDict*

`rtCommon.utils.loadMatFileFromBuffer`(*data*) → *rtCommon.structDict.MatlabStructDict*

`rtCommon.utils.find`(*A: numpy.ndarray*) → numpy.ndarray

Find nonzero elements of A in flat "C" row-major indexing order but sorted as in "F" column indexing order

`rtCommon.utils.loadConfigFile`(*filename*)

`rtCommon.utils.flatten_1Ds`(*M*)

`rtCommon.utils.dateStr30`(*timeval*)

`rtCommon.utils.md5SumFile`(*filePath*)

`rtCommon.utils.findNewestFile`(*filepath*, *filepattern*)

Find newest file matching pattern according to filesystem creation time. Return the filename

`rtCommon.utils.copyFileWildcard`(*src*, *dst*)

`rtCommon.utils.fileCount`(*dir*, *pattern*)

`rtCommon.utils.writeFile`(*filename*, *data*, *binary=True*)

`rtCommon.utils.readFile`(*filename*, *binary=True*)

`rtCommon.utils.deleteFilesFromList`(*fileList*)

`rtCommon.utils.deleteFolder`(*dir*)

`rtCommon.utils.deleteFolderFiles`(*dir*, *recursive=True*)

`rtCommon.utils.runCmdCheckOutput`(*cmd*, *outputRegex*)

`rtCommon.utils.demoDelay`(*demoStep*, *prevEventTime=None*)

Provides a delay of demoStep seconds from the previous event time (i.e. sleeps) Given demoStep in seconds, calculate how long to sleep until the next clock cycle will be reached that is an even value of demoStep. Then sleep that amount of time. If prevEventTime is specified and we are more than 1 demo step since the prevEvent then don't sleep.

`class rtCommon.utils.DebugLevels`

`L1 = 19`

`L2 = 18`

`L3 = 17`

`L4 = 16`

`L5 = 15`

`L6 = 14`

`L7 = 13`

`L8 = 12`

`L9 = 11`

`L10 = 10`

`rtCommon.utils.`**`installLoggers`**(*consoleLevel*, *fileLevel*, *filename=None*)

`rtCommon.utils.`**`gitCodeId`**

`rtCommon.utils.`**`getGitCodeId`**()

`rtCommon.utils.`**`stringPartialFormat`**(*text*, *tag*, *val*) → str

`rtCommon.utils.`**`trimDictBytes`**(*msg*, *trimSize=64*)

`rtCommon.utils.`**`getTimeToNextTR`**(*lastTrTime*, *trRepSec*, *nowTime*, *clockSkew*) → float

Returns seconds to next TR start time :param lastTrTime - datetime.time of the start of last TR: :param trRepSec - repetition time in seconds between TRs: :param nowTime - current time as datetime.time struct: :param clockSkew - seconds that scanner clock is ahead of caller clock:

Returns
seconds to next TR start (as float)

`rtCommon.utils.`**`dtimeToSeconds`**(*valTime*) → float

Given a datetime.time return seconds.fraction since day beginning

`rtCommon.utils.`**`calcAvgRoundTripTime`**(*pingFunc*)

Returns average round trip time in seconds

8.1.1.30 `rtCommon.validationUtils`

ValidationUtils - utils to help validate that arrays and data structures match. For example in testing and comparing to a known-good run from matlab.

Module Contents

Functions

compareArrays(A: numpy.ndarray, B: numpy.ndarray) → dict	Compute element-wise percent difference between A and B
areArraysClose(A: numpy.ndarray, B: numpy.ndarray, mean_limit=0.01, stddev_limit=1.0) → bool	Compare to arrays element-wise and compute the percent difference.
compareMatStructs(A: rtCommon.structDict.MatlabStructDict, B: rtCommon.structDict.MatlabStructDict, field_list=None) → dict	For each field, not like __*__, walk the fields and compare the values.
isMeanWithinThreshold(cmpStats: dict, threshold: float) → bool	Examine all ßmean stats in dictionary and compare to threshold value
compareMatFiles(filename1: str, filename2: str) → dict	Load both matlab files and call compareMatStructs.
pearsons_mean_corr(A: numpy.ndarray, B: numpy.ndarray)	

Attributes

numpyAllNumCodes
StatsEqual
StatsNotEqual

`rtCommon.validationUtils.`**`numpyAllNumCodes`**

`rtCommon.validationUtils.`**`StatsEqual`**

`rtCommon.validationUtils.`**`StatsNotEqual`**

`rtCommon.validationUtils.`**`compareArrays`**(*A: numpy.ndarray*, *B: numpy.ndarray*) → dict

Compute element-wise percent difference between A and B Return the mean, max, stddev, histocounts, histobins in a Dict

`rtCommon.validationUtils.`**`areArraysClose`**(*A: numpy.ndarray*, *B: numpy.ndarray*, *mean_limit=0.01*, *stddev_limit=1.0*) → bool

Compare to arrays element-wise and compute the percent difference. Return True if the mean and stddev are withing the supplied limits. Default limits:{mean: .01, stddev: 1.0}, i.e. no stddev limit by default

exception `rtCommon.validationUtils.`**`StructureMismatchError`**

Bases: `ValueError`

Inappropriate argument value (of correct type).

`rtCommon.validationUtils.`**`compareMatStructs`**(*A:* rtCommon.structDict.MatlabStructDict, *B:* rtCommon.structDict.MatlabStructDict, *field_list=None*) → dict

For each field, not like __*__, walk the fields and compare the values. If a field is missing from one of the structs raise an exception. If field_list is supplied, then only compare those fields. Return a dict with {fieldname: stat_results}.

`rtCommon.validationUtils.`**`isMeanWithinThreshold`**(*cmpStats: dict*, *threshold: float*) → bool

Examine all ßmean stats in dictionary and compare to threshold value

`rtCommon.validationUtils.`**`compareMatFiles`**(*filename1: str*, *filename2: str*) → dict

Load both matlab files and call compareMatStructs. Inspect the resulting stats_result to see if any mean is beyond some threshold. Also print out the stats results. Return the result stats.

`rtCommon.validationUtils.`**`pearsons_mean_corr`**(*A: numpy.ndarray*, *B: numpy.ndarray*)

8.1.1.31 `rtCommon.webDisplayInterface`

WebDisplayInterface is a client interface (i.e. for the experiment script running in the cloud) that provides calls that affect what is displayed in the users web browser. It is also used internally within projectServer for setting log and error messages within the web browser.

Module Contents

Classes

WebDisplayInterface

class `rtCommon.webDisplayInterface.`**`WebDisplayInterface`**(*ioLoopInst=None*)

`userLog`(*self*, *logStr*)

Set a log message in the user log area of the web page

`sessionLog`(*self*, *logStr*)

Set a log message in the session log area of the web page

`debugLog`(*self*, *logStr*)

Set a log message in the debug log area of the web page

`setUserError`(*self*, *errStr*)

Set an error message in the error display area of the web page

`setDebugError`(*self*, *errStr*)

Set an error message in the debug display area of the web page

`sendRunStatus`(*self*, *statusStr*)

Indicate run status in the web page

`sendUploadStatus`(*self*, *fileStr*)

`sendConfig`(*self*, *config*, *filename=''*)

Send the project configurations to the web page

`sendPreviousDataPoints`(*self*)

Send previously plotted data points to the web page

`plotDataPoint`(*self*, *runId*, *trId*, *value*)

Add a new data point to the web page plots

clearAllPlots(*self*)

Clear all data plots in the web page

clearRunPlot(*self*, *runId*)

Clear the data plot for the specfied run

getPreviousDataPoints(*self*)

Local command to retrieve previously plotted points (doesn't send to web page)

sendConnStatus(*self*)

Send the number of data and subject connections to the web page

wsConnCallback(*self*, *endpoint*, *cmd*)

Callback function for whenever a new websocket connection is established. Will track the number of connections in order to provide the connection status on the web page interface.

_addResultValue(*self*, *runId*, *trId*, *value*)

Track classification result values, used to plot the results in the web browser.

_sendMessageToWeb(*self*, *msg*)

Helper function used by the other methods to send a message to the web page

8.1.1.32 `rtCommon.webHttpHandlers`

This module provides the callback handlers that the web server will utilize

when handling and rendering html page reqeusts.

Module Contents

Classes

HttpHandler	Generic web handler object that is initialized with the page name to render when called.
LoginHandler	Renders a login page and authenticates users. Sets a secure-cookie to remeber authenticated users.
LogoutHandler	Clears the secure-cookie so that users will need to re-authenticate.

Functions

loadPasswdFile(filename)
storePasswdFile(filename, passwdDict)

Attributes

maxDaysLoginCookieValid

`rtCommon.webHttpHandlers.`**`maxDaysLoginCookieValid = 0.5`**

class `rtCommon.webHttpHandlers.`**`HttpHandler`**

Bases: `tornado.web.RequestHandler`

Generic web handler object that is initialized with the page name to render when called.

`initialize`(*self*, *htmlDir*, *page*)

`get_current_user`(*self*)

`get`(*self*)

Handle a web GET request by returning the appropriate web content to render

class `rtCommon.webHttpHandlers.`**`LoginHandler`**

Bases: `tornado.web.RequestHandler`

Renders a login page and authenticates users. Sets a secure-cookie to remeber authenticated users.

`loginAttempts`

`loginRetryDelay = 10`

`initialize`(*self*, *htmlDir*, *page*, *testMode*)

`get`(*self*)

`post`(*self*)

`checkRetry`(*self*, *user*)

Keep a dictionary with one entry per username. Any user not in the passwd file will be entered as 'invalid_user'. Record login failure count and timestamp for when the next retry is allowed. Reset failed retry count on successful login. Return message with how many seconds until next login attempt is allowed.

class `rtCommon.webHttpHandlers.`**`LogoutHandler`**

Bases: `tornado.web.RequestHandler`

Clears the secure-cookie so that users will need to re-authenticate.

`initialize`(*self*)

`get`(*self*)

`rtCommon.webHttpHandlers.`**`loadPasswdFile`**(*filename*)

`rtCommon.webHttpHandlers.`**`storePasswdFile`**(*filename*, *passwdDict*)

8.1.1.33 rtCommon.webServer

Web Server module which provides the web user interface to control and monitor experiments

Module Contents

Classes

Web	Cloud service web-interface that is the front-end to the data processing.
WsBrowserRequestHandler	Command handler for commands that the javascript running in the web browser can call

Functions

procOutputReader(proc, lineQueue)	Read output from runSession process and queue into lineQueue for logging
getCookieSecret(dir)	Used to remember users who are currently logged in.

Attributes

CommonOutputDir
moduleDir
rootDir
logger

rtCommon.webServer.**CommonOutputDir = /rtfmriData/**

rtCommon.webServer.**moduleDir**

rtCommon.webServer.**rootDir**

rtCommon.webServer.**logger**

class rtCommon.webServer.**Web**

Cloud service web-interface that is the front-end to the data processing.

app

httpServer

started = False

httpPort = 8888

`webDir`

`htmlDir`

`ioLoopInst`

`testMode = False`

`webDisplayInterface`

static start(*params*, *cfg*, *testMode=False*)

Start the web server running. Function does not return.

static addHandlers(*handlers*)

static stop()

Stop the web server.

static close()

class rtCommon.webServer.WsBrowserRequestHandler(*webDisplayInterface*, *params*, *cfg*)

Command handler for commands that the javascript running in the web browser can call

_addScript(*self*, *name*, *path*, *type*)

Add the experiment script to be connected to the various run button of the web page. These include 'mainScript' for classification processing, 'initScript' for session initialization, and 'finalizeScript' for any final processing at the end of a session.

on_getDefaultConfig(*self*)

Return default configuration settings for the project

on_getDataPoints(*self*)

Return data points that have been plotted

on_getRunStatus(*self*)

Return run status from the project server

on_clearDataPoints(*self*)

Clear all plot datapoints

on_runScript(*self*, *name*)

Run one of the project scripts in a separate process

on_stop(*self*)

Stop execution of the currently running project script (only one can run at a time)

on_uploadFiles(*self*, *request*)

Upload files from the dataServer to the cloud computer

_wsBrowserCallback(*self*, *client*, *message*)

The main message handler for messages received over web sockets from the web page javascript. It will parse the message and call the corresponding function above to handle the request.

_runSession(*self*, *cfg*, *pyScript*, *tag*, *logType='run'*)

Run the experimenter provided python script as a separate process. Forward the script's printed output to the web page's log message area.

_uploadFilesHandler(*self*, *request*)

Handle requests from the web interface to upload files to this computer.

_setError(*self*, *errStr*)

rtCommon.webServer.**procOutputReader**(*proc*, *lineQueue*)

Read output from runSession process and queue into lineQueue for logging

rtCommon.webServer.**getCookieSecret**(*dir*)

Used to remember users who are currently logged in.

8.1.1.34 rtCommon.webSocketHandlers

This module provides classes for handling web socket communication in the web interface.

Module Contents

Classes

websocketState	A global static class (really a struct) for maintaining connection and callback information.
BaseWebSocketHandler	Generic web socket handler. Estabilishes and maintains a ws connection. Intitialized with
DataWebSocketHandler	Sub-class the base handler in order to clean up any outstanding requests on close.
RejectWebSocketHandler	A web socket handler that rejects connections on the web socket and returns a
RequestHandler	Class for handling remote requests (such with a remote DataInterface). Each data requests is

Functions

sendWebSocketMessage(wsName, msg, conn=None)	Send messages from the web server to all clients connected on the specified wsName socket.
closeAllConnections()	
defaultWebsocketCallback(client, message)	

class rtCommon.webSocketHandlers.**websocketState**

A global static class (really a struct) for maintaining connection and callback information.

wsConnLock

wsConnectionLists

wsCallbacks

class rtCommon.webSocketHandlers.**BaseWebSocketHandler**

Bases: tornado.websocket.WebSocketHandler

Generic web socket handler. Estabilishes and maintains a ws connection. Intitialized with
a callback function that gets called when messages are received on this socket instance.

initialize(*self*, *name*, *callback=None*, *connNotify=None*)

initialize method is called by Tornado with args provided to the addHandler call

Parameters

- **name** – the websocket endpoint name, such as wsData
- **callback** – the handler function to call whenever a client message is received over the connection.
- **connNotify** – the function to call when a connection is opened or closed.

open(*self*)

Called when a new client connection is established

on_close(*self*)

Called when the client connection is closed

on_message(*self*, *message*)

Called when a message is received from a client connection

class rtCommon.webSocketHandlers.**DataWebSocketHandler**

Bases: *BaseWebSocketHandler*

Sub-class the base handler in order to clean up any outstanding requests on close.

on_close(*self*)

Called when the client connection is closed

class rtCommon.webSocketHandlers.**RejectWebSocketHandler**

Bases: tornado.websocket.WebSocketHandler

A web socket handler that rejects connections on the web socket and returns a pre-configured error with the rejection reason.

initialize(*self*, *rejectMsg*)

open(*self*)

rtCommon.webSocketHandlers.**sendWebSocketMessage**(*wsName*, *msg*, *conn=None*)

Send messages from the web server to all clients connected on the specified wsName socket.

rtCommon.webSocketHandlers.**closeAllConnections**()

rtCommon.webSocketHandlers.**defaultWebsocketCallback**(*client*, *message*)

class rtCommon.webSocketHandlers.**RequestHandler**(*name*, *ioLoopInst*)

Class for handling remote requests (such with a remote DataInterface). Each data requests is given a unique ID and callbacks from the client are matched to the original request and results returned to the corresponding caller.

doRequest(*self*, *msg*, *timeout=None*)

Send a request over the web socket, i.e. to the remote FileWatcher. This is typically the only call that a user of this class would make. It is the highest level call of this class, it uses the other methods to complete the request.

prepare_request(*self*, *msg*)

Prepate a request to be sent, including creating a callback structure and unique ID.

callback(*self*, *client*, *message*)

Recieve a callback from the client and match it to the original request that was sent.

get_response(*self*, *callId*, *timeout=None*)

Client calls get_response() to wait for the callback results to be returned.

close_pending_requests(*self*)

Close requests and signal any threads waiting for responses.

pruneCallbacks(*self*)

Remove any orphaned callback structures that never got a response back.

8.1.1.35 rtCommon.wsRemoteService

An RPC server base class for encapsulating a service class and receiving requests that will call that encapsulated class. This is part of a remote service that communicates with the projectServer.

Module Contents

Classes

WsRemoteService

Functions

isNativeType(var)
parseConnectionArgs()

class rtCommon.wsRemoteService.**WsRemoteService**(*args*, *channelName*)

remoteHandler

commLock

shouldExit = False

addHandlerClass(*self*, *classType*, *classInstance*)

Register the class that will handle the received requests via the class type

addHandlerClassName(*self*, *className*, *classInstance*)

Register the class that will handle the received requests via the class name

runForever(*self*)

Run the receiver loop. This function doesn't return.

static **stop**()

static **send_response**(*client*, *response*)

static handle_request(*client*, *message*)

Handle requests from the projectServer. It will call the registered handler to process the request and then return the result back to the projectServer.

static on_message(*client*, *message*)

Main message dispatcher that will get a request from projectServer and start a thread to handle the request.

static on_error(*client*, *error*)

static on_close(*client*, *code*, *reason*)

rtCommon.wsRemoteService.**isNativeType**(*var*)

rtCommon.wsRemoteService.**parseConnectionArgs**()

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