StrokeSENS Software Integration Guide

Version 2.2

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Contents

1. What is StrokeSENS?

 StrokeSENS is a decision-aid software package to be used by clinicians to perform image processing of contrast-enhanced computed tomography (CT) scans of the brain in patients with suspected acute stroke. Analysis is provided by the StrokeSENS LVO, StrokeSENS ASPECTS, and StrokeSENS mCTA modules.

> ⚠️ **IMPORTANT**: No known susceptibilities to other software applications have been identified, however, it is the end-user's responsibility to ensure the environment in which the StrokeSENS application is installed is maintained and free of other applications that may jeopardize the safe and effective use of the software.

> ⚠️ **IMPORTANT**: StrokeSENS undergoes rigorous Cybersecurity and Systems testing prior to release. Once deployed on-site, the security and connectivity of the StrokeSENS system within the hospital IT infrastructure is the responsibility of the on-site/customer's IT and Security professionals.

2. What is the purpose of this document?

This document gives an overview of the main components and deployment strategy to install the StrokeSENS Docker container image for on-prem and cloud deployments. Also included are the minimum hardware and software specifications.

3. Overview of StrokeSENS

Image data is acquired through Digital Imaging and Communication in Medical Images (DICOM)-compliant imaging devices prior to processing in StrokeSENS. There are two mechanisms by which DICOM images are received: the DICOM protocol or through a REST API call. It is designed to handle multiple concurrent studies to enable fast collaboration among physicians during acute stroke treatments. Results are generated as human readable DICOM outputs and are exported to configured environments. Machine-readable JSON files are generated alongside the DICOM results to allow for easy integration with host environment notification systems. The JSON file content is also returned within the REST API callback.

The StrokeSENS docker container image may be installed for on-prem partner solutions, or for cloud-based offerings.

StrokeSENS consists of:

1. A **DICOM Service** to receive stroke image inputs and return image-based post-processing results via a single input connection and multiple output connections using the DICOM protocol.
2. A **REST API Service** to receive status, ASPECTS modify, and study processing requests containing input/output directory of DICOM files and Callback API. Callback API is called to indicate processing completion.
3. A **License Service** to handle the activation of the available StrokeSENS modules.
4. The **StrokeSENS Libraries** to process stroke images and generate decision supporting DICOM image and JSON key/value outputs.
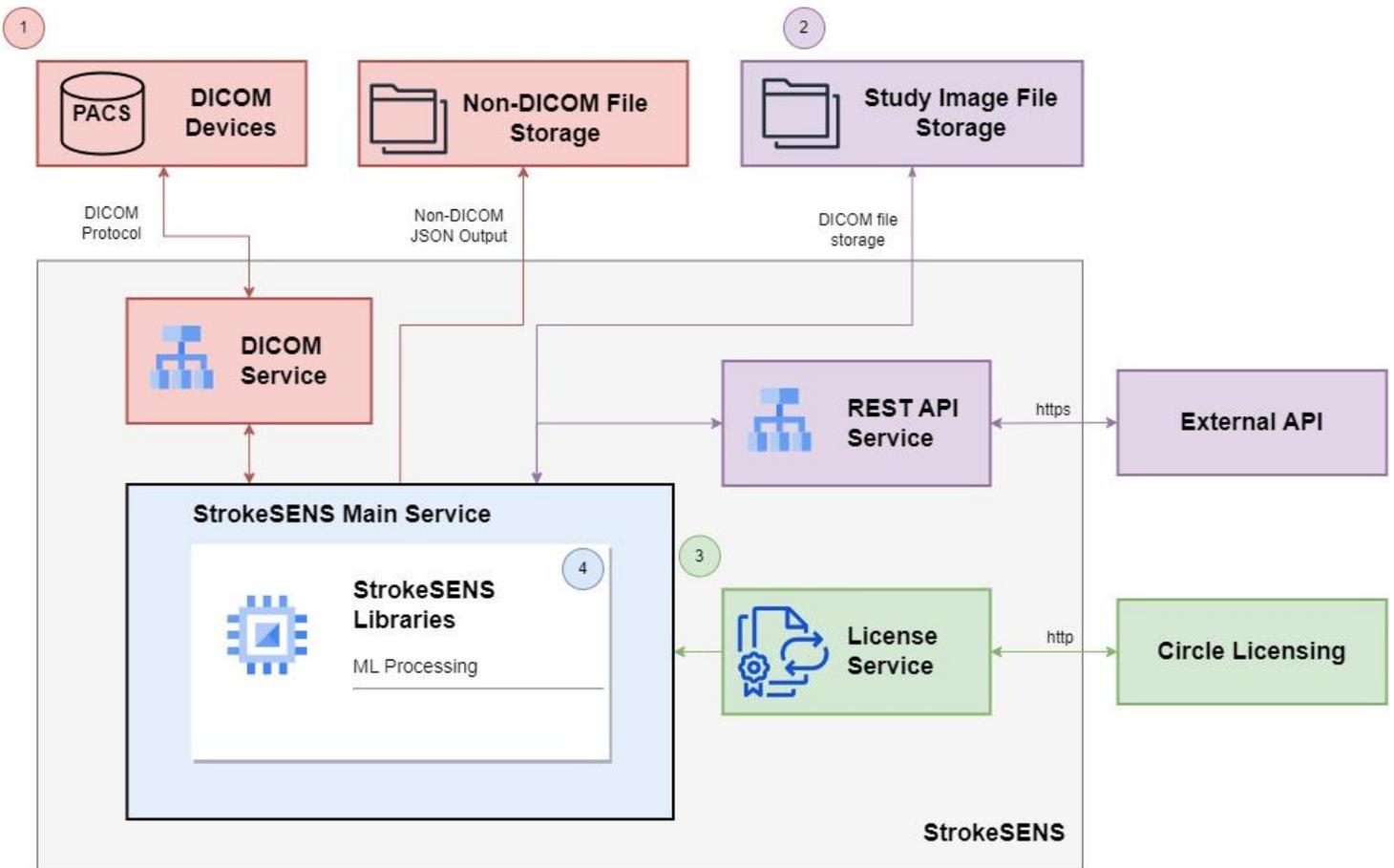
StrokeSENS system Architecture

DICOM protocol data flow:
- DICOM study images are received via the DICOM protocol (see **Section 8 Configuration Settings).**
- DICOM study images are automatically sent for processing in the StrokeSENS Libraries.
- Post-processing results are exported via the DICOM protocol to configured clinical environments (see **Section 8 Configuration Settings**).

REST API data flow:
- Integration partner calls the POST /process API indicating the **input/output** directory for DICOM files and the callback URL endpoint. (see **Section 8 Configuration Settings**).

- DICOM study images are picked up from **input** directory and are automatically processed by the StrokeSENS Libraries.
- Post-processing output DICOM images are stored in the **output** directory.
- The REST API callback indicates processing completion and includes results.

Licensing:
- Online Licensing utilizes an activation key and must have internet connection to connect to Circle's licensing backend. (See **Section 8 Configuration Settings**).
- Offline Licensing allows installations without internet connection to become licensed with an offline license file.
- To enable a StrokeSENS module the license for that module must be owned.

The LVO outputs consist of:
- Two DICOM post-processing result images
  - ImageType = DERIVED/SECONDARY/PROCESSED
  - Modality = CT
  - Contents:
    - Instance Number 1: A Maximum Intensity Projection (MIP) of the input CTA image centered at the large vessel area. If "Positive" for LVO, "Suspected LVO Identified" is visible on the top of the image.
    - Instance Number 2: Text information related to input image, processing information, and StrokeSENS device information.

- JSON key/value output
  - Generated on either case of LVO suspected or not.
  - Contents:
    - All the information found in the DICOM image of patient and processing information.
    - Note that the "Results" section will say "Suspected LVO Identified" in the case of a positive LVO and it will be left blank when no LVO is suspected.

The ASPECTS outputs consist of:
- (up to) 38 DICOM auto-generated post-processing result images
  - ImageType = DERIVED/SECONDARY/PROCESSED
  - Modality = CT
  - Contents:
    - Instance Number 1: **Not auto generated.** Reserved for user modify/verification image. (See Modify/Verify ASPECTS output section below)
    - Instance Number 2-37*: Reconstructed NCCT images with overlaid regions, as well as ASPECTS score, affected side, and affected region information. *max 36 images (Instances 2-37). Number of images will vary depending on original series FOV.
    - Instance Number 38*: Text information related to input image, processing information, and StrokeSENS device information. *always last slice, exact instance number will depend on original series FOV.

- JSON key/value output
  - Contents:
    - All the information found in the DICOM image of patient and processing information.
    - ASPECTS affected side.
    - ASPECTS affected regions.

Modify/Verify ASPECTS output:
- 1 DICOM result image
  - ImageType = DERIVED/SECONDARY/PROCESSED
  - Modality = CT
    - Instance Number 1: User modified or verified ASPECTS Score, affected side, affected regions, and regions illustration.
    - More information can be found in Section 9.2.2.3 of the User Manual.

mCTA output:
- One output series stack of processed result images representing both the mCTA RGB and Peak Phase maps
  - ImageType = DERIVED/SECONDARY/PROCESSED
  - Modality=CT
  - Contents:
    - For each orientation (axial/coronal/sagittal), there will be one DICOM series for the combined output, one series for each mCTA phase, one series for the mCTA RGB, and one for the mCTA peak phase volume.
- No JSON key/value output available

4. Deployed system diagrams

On-Premises Configuration
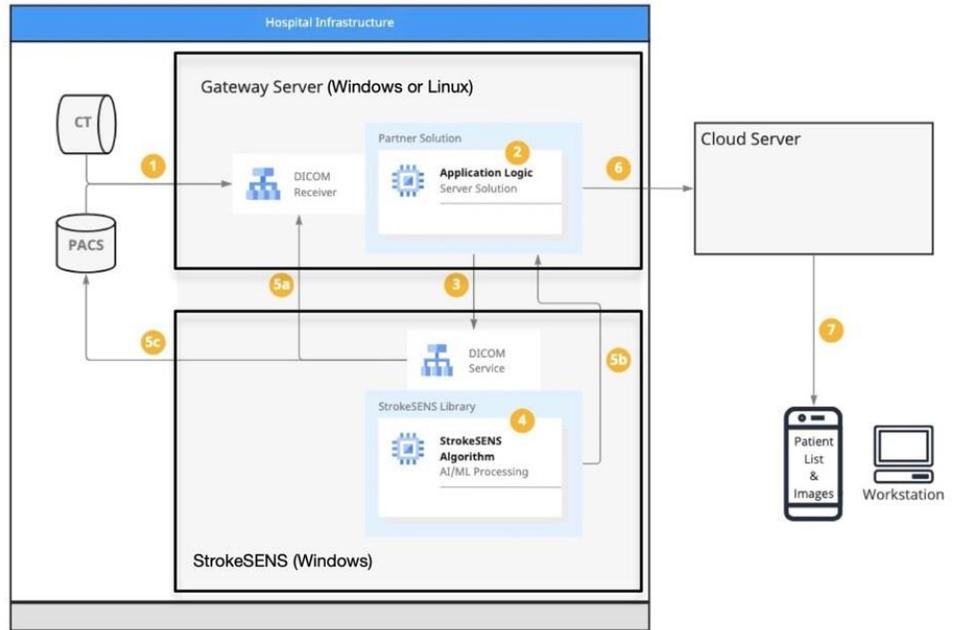
StrokeSENS integrated with on-premise Radiological Environment or Partner's Gateway Server

Cloud-Based Configuration

StrokeSENS can be integrated in cloud-based server environment outside of the hospital infrastructure.
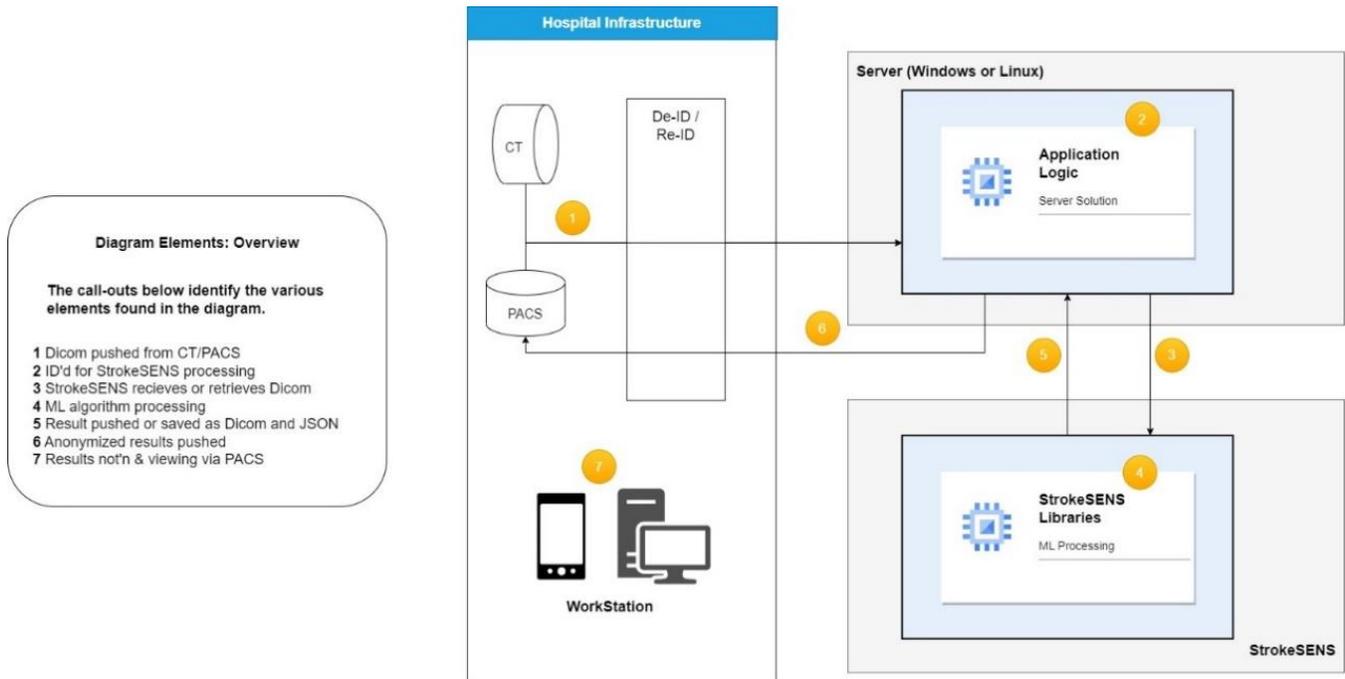
StrokeSENS integrated with a Partner's Cloud Server

Both systems have the same input/output formats:

StrokeSENS takes as input(#3):
- Acute CT DICOM images for patients with suspected stroke
  - Mechanism: Received via DICOM push or POST /process API

StrokeSENS generates as output (#5):
- DICOM Secondary Capture results from image processing (#5)
  - Mechanism: Sent via DICOM push or the REST API callback

- Structured key-value data for non-image results (ex. Content for notifications) (#5)
  - Mechanism: Stored in user-configured path within local file storage system and sent in REST API callback (if applicable) in JSON format

Refer to section 8 for Configuration Settings.

5. System hardware and software specifications

The following specifications need to be met for the StrokeSENS Docker Container system to correctly perform analysis.

Requirement	Recommendations
CPU	Intel(R) Xeon(R) CPU E5-2680 v3 @ 2.50Hz, 2500 Mhz, 4 Core(s), 4 Logical Processor(s) (Analysis of a single study requires 2 cores to support incoming studies, and an additional 2 cores to perform machine learning computation tasks)
RAM	16 GB DDR3 to support study analysis (or better for faster processing)
Storage	64 GB SSD (Depending on the number and the sizes of studies stored, this number may be varied.)
OS	Linux Kernel 3.10 minimum requirement for Docker
Network	1 GB ethernet minimum

6. Integration process

StrokeSENS is delivered as a Linux Docker image:
- Configuration for DICOM input and output as well as advanced settings are set by manually editing config file and mounting as a volume at container runtime.
- Image may be run on Linux OS or Windows OS as long as minimum requirement for Linux Kernel 3.10 is met.

Containerized Solution (Docker)

A Linux Docker image version of StrokeSENS can be received from the Circle upon request. This requires that Docker be installed and able to run Linux containers.

The StrokeSENS Docker container requires bind mounts for accessing internal folders, and certain ports to be published for communication. Access to internal folders is required to provide a config file updated with site configuration information. Other folders may be mounted to access log files, license files, or algorithm outputs.
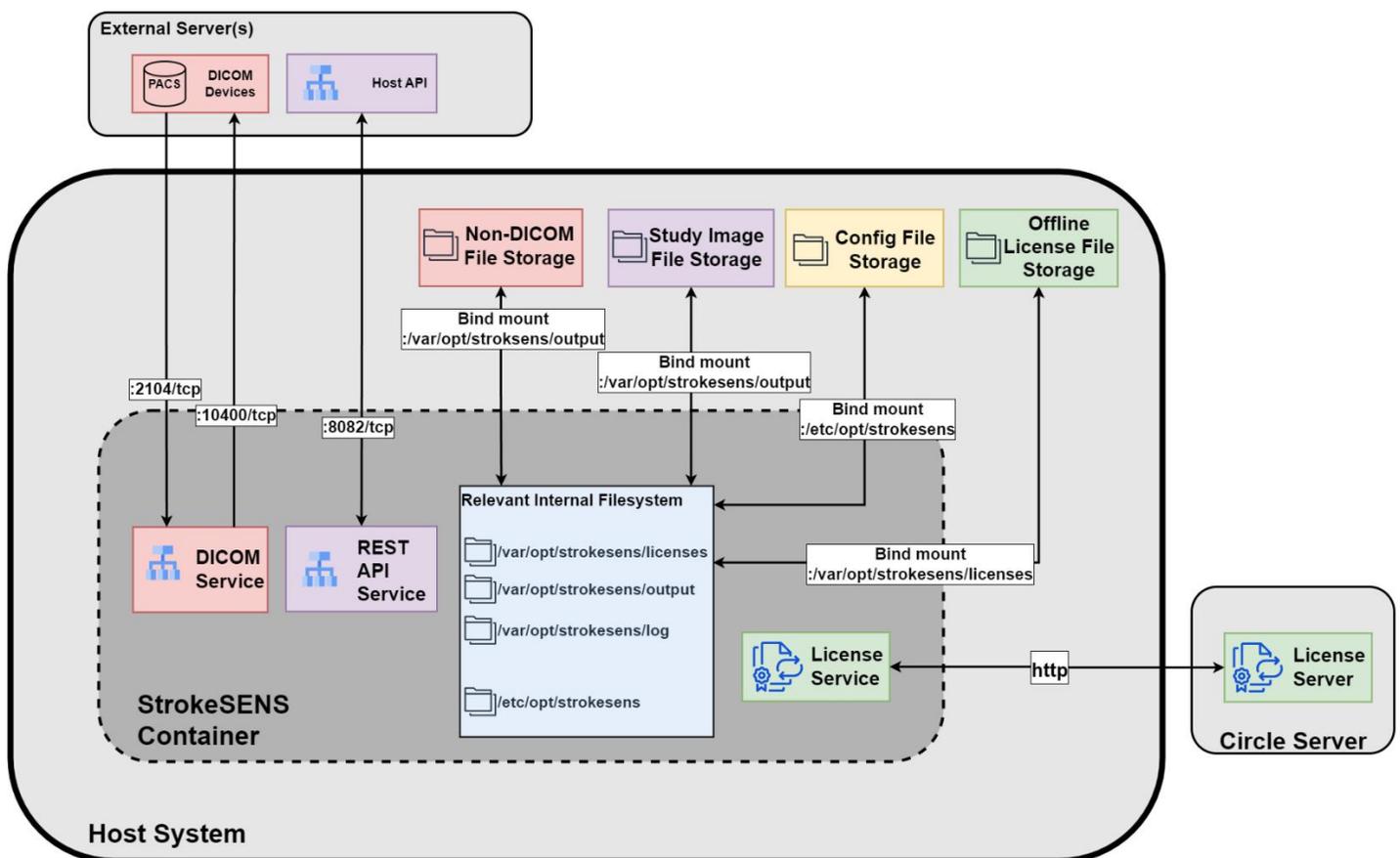
System diagram of StrokeSENS Docker container, including important filesystem locations and ways to access internal services

Bind Mounts:

These are configurable through the config file, see Section 8 *Configuration Settings* for more details.

Config folder: Contains the config file. The default config folder inside the container is "/etc/opt/strokesens/".

Example usage in Docker run command:
    -v ~/StrokeSENS_mounts/config:/etc/opt/strokesens/

JSON output folder: Contains JSON output file for each study processed. Mount the NonDicomOutputPath to a local folder. The default NonDicomOutputPath in the container is "/var/opt/strokesens/output".

Example usage in Docker run command:
    -v ~/StrokeSENS_mounts/output:/var/opt/strokesens/output

Log folder: Contains JSON file outputs for each study processed. Mount the LogDirectory to a local folder. The default LogDirectory in the container is "/var/opt/strokesens/log".

Example usage in Docker run command:
    -v ~/StrokeSENS_mounts/log:/var/opt/strokesens/log

Licenses folder: Contains license files, required to mount for using offline license. Mount the LicesneDirectory to a local folder. The default LicenseDirectory in the container is "/var/opt/strokesens/licenses".

Example usage in Docker run command:
    -v ~/StrokeSENS_mounts/licenses:/var/opt/strokesens/licenses

Published Ports:

These are configurable through the config file, see Section 8 *Configuration Settings* for more details

Incoming PACS Port: To send DICOM files to StrokeSENS via DICOM protocol, the Incoming PACS Port needs to be published to the host system. The default Incoming PACS Port is "2104"

Example usage in Docker run command:
    -p 2104:2104

Export DICOM Node Port: To receive DICOM outputs from StrokeSENS via DICOM protocol, the Export DICOM Node Port needs to be published to the host system. The default Export DICOM Node Port is "10400"

Example usage in Docker run command:
    -p 10400:10400

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Web Port (for Rest API): To access the StrokeSENS Rest API, the Web Port needs to be published to the host system. The default Web Port is "8082"

Example usage in Docker run command:
-p 8082:8082

Basic Setup Instructions:

The following instructions assume no container manager (e.g. Kubernetes); please contact support (see section *14 Support*) if using a container management system.

1. Load the StrokeSENS Docker image from the tar.gz file

```
[luke@gecentos Downloads]$ docker image load --input strokesens_2.1.0-255.tar.gz
d5c1a9d0b1e5: Loading layer [==================================================>]  123.3MB/123.3MB
e3bd600a7f06: Loading layer [==================================================>]  218.5MB/218.5MB
ee50775346c0: Loading layer [==================================================>]    7.68kB/7.68kB
94188819d43f: Loading layer [==================================================>]  1.413GB/1.413GB
aeb2b029fc05: Loading layer [==================================================>]  6.144kB/6.144kB
98a3a1305749: Loading layer [==================================================>]  4.608kB/4.608kB
5f70bf18a086: Loading layer [==================================================>]  1.024kB/1.024kB
Loaded image: strokesens:2.1.0-255
```

Example of loading the StrokeSENS image from tar.gz

2. Create a config folder to mount into the container as a volume at runtime.
3. Place the config file in the config folder.

```
[luke@gecentos ~]$ mkdir StrokeSENS_mounts/config
[luke@gecentos ~]$ cp Downloads/config.ini StrokeSENS_mounts/config/
[luke@gecentos ~]$ find StrokeSENS_mounts/
StrokeSENS_mounts/
StrokeSENS_mounts/config
StrokeSENS_mounts/config/config.ini
[luke@gecentos ~]$
```

Example of creating config folder and placing config file inside

4. Setup licensing:
    StrokeSENS provides two forms of licensing. For online licensing continue with step 4A. For offline licensing continue with step 4B.

A. Online licensing setup:
    a. Write Circle provided license activation key to "OnlineActivation\ActivationKey=" in config file (See section 8 *Configuration Settings* for more info)

```
[Licensing]
OnlineActivation\ActivationKey=1234-5678-8765-4321
OnlineActivation\PeriodicDays=7
```

Example of license key formatting in config file

B. Offline licensing setup:
   a. Create a licenses folder to mount into the container at runtime.
   b. Place offline licenses in licenses folder.

```
[luke@gecentos ~]$ mkdir StrokeSENS_mounts/licenses
[luke@gecentos ~]$ cp Downloads/*.lic StrokeSENS_mounts/licenses/
[luke@gecentos ~]$ find StrokeSENS_mounts/
StrokeSENS_mounts/
StrokeSENS_mounts/config
StrokeSENS_mounts/config/config.ini
StrokeSENS_mounts/licenses
StrokeSENS_mounts/licenses/1234-5678-8765-4321_2024-09-07_strokesens-server_v2.lic
StrokeSENS_mounts/licenses/1234-5678-8765-4321-A_2024-09-07_strokesens-lvo.lic
StrokeSENS_mounts/licenses/1234-5678-8765-4321-B_2024-09-07_strokesens-aspects.lic
StrokeSENS_mounts/licenses/1234-5678-8765-4321-V_2024-09-07_rlm_server_enable.lic
[luke@gecentos ~]$
```

Example of placing license files in licenses folder

Example usage in Docker run command:
-v ~/StrokeSENS_mounts/licenses:/etc/opt/strokesens/licenses

5. MAC address of host machine will need to be specified at container runtime to guarantee licensing works if container restarts. If using offline licensing a designated MAC address will be provided by Circle Support.

   Commands to find MAC address of eth0 through bash terminal:
   - *ifconfig -a*
   - *ip a*
   - *IFACE=eth0; read MAC </sys/class/net/$IFACE/address; echo $IFACE $MAC*

   Example usage in Docker run command:
   --mac-address 12:34:56:78:9a:bc

6. Start the container using the Docker run command with options as needed.

   Example Docker run command:
   docker run --name StrokeSENS --mac-address 12:34:56:78:9a:bc -v ~/StrokeSENS_mounts/config:/etc/opt/strokesens/ -p 2104:2104 -p 10400:10400 -p 8082:8082 strokesens:2.1.0-255

7. Configuration Settings

When updating values in the config file, the user must restart the StrokeSENS service, or StrokeSENS Docker container to ensure new values are loaded.

Incoming PACS Settings

The StrokeSENS application may receive study DICOM images through the DICOM protocol. Upon installation, the site admin or host application system can customize the **Incoming Server AETitle** and **Incoming Server Port,** otherwise these keys will be left as the default values. Any studies destined for processing by StrokeSENS will need to be routed to these incoming PACS settings. All DICOM images sent to StrokeSENS will automatically be processed.

```
[incomingPacs]
Port=2104
AETitle=StrokeSENS
AcceptsUnknownAEs=true
AcceptsUnknownSOPs=true
AcceptsUnspecifiedImplementationID=true
MaxConnections=10
```

The incoming PACS settings are stored in the config.ini file under the **incomingPacs** heading as seen below.

There are supplemental settings for incoming PACS that the site admin may configure at any time. It is important to note that for changes to take effect the StrokeSENS service will have to be restarted.

AcceptsUnknownAEs default is true, allowing incoming PACS to accept entities with unknown AE titles. Change to false when incoming PACS should not be accepting connections with unknown AE titles.

AcceptUnknownSOPs default is true, allowing for connections with unknown SOP classes. Change to false when incoming PACS should not accept connections with unknown SOP classes.

AcceptsUnspecifiedImplementationID default is true, allowing incoming PACS to accept connections with unspecified implementation UIDs. Change to false when incoming PACS should not accept connections with unspecified implementation UIDs.

MaxConnections default is 10, allowing for a maximum of 10 connections to be maintained with incoming PACS at one time. Adjust when max number of connections needed to be maintained at once is to change.

General Settings

The StrokeSENS application has a logging system which allow users to understand and troubleshoot any errors that may occur during its use. These logs can be found in the log directory which will either be set

through custom installation or defaulted to "/var/opt/strokesens/log". For more information on logging refer to Section 9.

StrokeSENS uses a temporary directory as part of the DICOM importing process. This temporary directory path is set as the default path "/var/opt/strokesens/temp", however can also be set at custom installation.

StrokeSENS licensing uses a default directory for storing and finding license files, which can either be set at installation or through the config file. If not set the license directory will be defaulted to location "/var/opt/strokesens/licenses". For users with online licensing, generated license files will appear at this location, and for offline licensed users, ensure licenses are placed in this directory so that StrokeSENS can run properly.

The temporary, log, and license directory paths can also be configured in the config file under the **generalSettings** heading, under the names of **TempDirectory, LogDirectory**, and **LicenseDirectory**, respectively.

```
[generalSettings]
ShortTermStudyStorageTimeMins=5
IncomingStudyDataWaitTimeSecs=20
LogDirectory=/var/opt/strokesens/log
TempDirectory=/var/opt/strokesens/temp
LicenseDirectory=/var/opt/strokesens/licenses
```

Along with these directories, the general settings portion of the config file also includes some supplemental settings study processing that a system admin may configure at any time. It is important to note that for changes to take effect the StrokeSENS service will have to be restarted.

ShortTermStudyStorageTimeMins default is 5, which will start a timer of the set number of minutes once a study's results have been exported. This will allow for partial data to continue to come in, even after results are exported. Adjust when storage time is to be increased or decreased. Note that **ShortTermStudyStorageTimeMins** must be a value between 0 to 10 minutes. If a value under 0 is inputted a value of 5 will be used, and if a value over 10 is inputted a value of 10 will be used instead. The final value being used by StrokeSENS can be found in the startup logs as seen in Section 9.

IncomingStudyDataWaitTimeSecs default is 20, which will start a timer that waits to trigger the call that all data for a study has been received. Adjust when increasing or decreasing wait time depending on the study. Note that **IncomingStudyDataWaitTimeSecs** must be a value between 0 to 60 seconds. If a value under 0 is inputted a value of 20 will be used, and if a value over 60 is inputted a value of 60 will be used instead. The final value being used by StrokeSENS can be found in the startup logs as seen in Section 9.

Licensing Settings

StrokeSENS may be licensed using two methods: Online licensing and Offline licensing. The config file includes settings that are used for both licensing methods under the **Licensing** header.

```
[Licensing]
OnlineActivation\ActivationKey=1234-5678-8765-4321
OnlineActivation\PeriodicDays=7
LicenseRequest\customerName=
LicenseRequest\institutionName=
LicenseRequest\contactEmail=
LicenseRequest\beginDate=
LicenseRequest\exportPath=
```

For online licensing the following settings apply:

OnlineActivation\ActivationKey where the activation key will be placed. Circle Support will provide the activation key, along with StrokeSENS, for online licensing.

OnlineActivation\PeriodicDays default of 7 days, the period in which the license will call to the server in case of licensing updates. This setting has a minimum value of 0 days and a maximum value of 365 days. If the value is beyond this range, a default value of 7 will be assumed instead.

For offline licensing the following settings apply:

An offline license request form will be created using the following settings, if licensing cannot be found. The request form can then be sent to Circle Support to receive license files. The following settings are required for the request form to be filled out properly.

LicenseRequest\customerName name of customer to be used for Offline License Request form.

LicenseRequest\institutionName name of institution to be used for Offline License Request form.

LicenseRequest\contactEmail email of contact to be used for Offline License Request form.

LicenseRequest\beginDate date to be used as the start of Licensing period, to be used for Offline License Request form.

LicenseRequest\exportPath path where the Offline License Request form will be placed in StrokeSENS start.

Language Settings

```
[Language]
SelectedLanguage=en
```

StrokeSENS provides language support for 6 different languages in the produced DICOM outputs. The supported language can be altered through the config file using the **SelectedLanguage** setting under the **Language** heading. The **SelectedLanguage** setting takes on ISO 639-1 standard language code. Supported language codes include:

- **en** for English
- **fr** for French
- **it** for Italian
- **de** for German
- **es** for Spanish
- **pt** for Portuguese

REST API Settings

StrokeSENS provides a REST API which can be called upon **to** retrieve or send information**.** For further insight on these requests go to Section 9 of the User Manual. The configuration file allows users to set ports and settings for the API under the REST API heading. See Section 9 for more details on the available APIs.

```
[RestAPI]
WebPort=8082
TcpPort=49697
CallbackRetries=3
```

WebPort, defaults at 8082, is the port that will be used to establish the web connection for the Rest API.

TcpPort, defaults at 49697, is the port used internally by StrokeSENS. It may be changed if it conflicts with other ports in the system.

CallbackRetries, defaults at 3, is the amount of callback requests that will be sent by the REST API when it fails to connect to the callback URL. The minimum amount of retries is 0, and any value less than that in the config file will automatically default to 0 retries. The maximum amount of retries is 10, and any value higher than that in the config file will automatically default back to 10 retries.

LVO, ASPECTS, and mCTA Peak Phase Settings (Default Classifier and Classifier Bypass)

All study DICOM images received by the StrokeSENS application will be sorted by a default classification algorithm. This serves to retrieve the adequate head CT volume for processing by the StrokeSENS modules. The criteria for the default classifier are as follows:

NCCT for ASPECTS
1. Modality = CT
2. Orientation = Axial (calculated from the Image Orientation Patient DICOM tag)
3. Image Type = Original/Primary
4. Field of View along the Z axis > 50 mm
5. Volumes = 1
6. Window Width <= 210

* Note: Modality and Orientation are hard requirements, i.e., Can not be bypassed via the classifier bypass
* Note: if a study contains both a thick and thin NCCT series that meet the criteria above, the thick NCCT series (slice thickness of >=2.5 mm) will be prioritized for processing over the thin NCCT series (slice thickness <2.5 mm).

CTA for LVO Detection
1. Modality = CT
2. Orientation = Axial (calculated from the Image Orientation Patient DICOM tag)
3. Image Type = Original/Primary
4. Field of View along the Z axis > 50 mm
5. Volumes = 1 or 3 *A multi-volume CTA (i.e. multi-phase CTA), with 3 phases only, is acceptable. Only the first phase will be used for processing. If the 3 CTA volumes are provided as separate series, the Acquisition Data and Acquisition Time (or Acquisition DateTime) DICOM tags must be specified to identify the earliest series.
6. 210 < Window Width <= 1200

* Note: Modality and Orientation are hard requirements, i.e., Can not be bypassed via the classifier bypass

mCTA for mCTA Peak Phase
1. Modality = CT
2. Orientation = Axial (calculated from the Image Orientation Patient DICOM tag)
3. Image Type = Original/Primary
4. Field of View along the Z axis > 50 mm
5. **Multi-phase CTA**: Volumes = 3 * If a multi-phase CTA is provided, exactly 3 phases are required. All three phases will be used for processing. If the 3 CTA volumes are provided as separate series, the Acquisition Data and Acquisition Time (or Acquisition DateTime) DICOM tags must be specified for the system to combine the three volumes into a manual multi-phase CTA.
6. **NCCT**: Window Width <= 210

mCTA: 210 < Window Width <= 1200

* Note: Modality and Orientation are hard requirements, i.e., Can not be bypassed via the classifier bypass

Note, studies that do not contain a series that satisfies the above criteria will not be processed. This will simply be logged, and no result will be produced.

If the default classifier fails to correctly classify a series that the user thinks should be processed by any of the StrokeSENS modules, then the site admin may configure the **ClassifierBypass** in the config file to selectively sort the incoming DICOMs based on the Series Description of the input DICOMs. These settings can be found in the config file as shown below.

```
[LVO]
ClassifierBypass\SeriesDescription1=

[ASPECTS]
ClassifierBypass\SeriesDescription1=

[mCTAp]
ClassifierBypass\NCCT\SeriesDescription1=
ClassifierBypass\CTA1\SeriesDescription1=
ClassifierBypass\CTA2\SeriesDescription1=
ClassifierBypass\CTA3\SeriesDescription1=
```

To configure automatic selection of input DICOMs for processing via the ClassifierBypass, write the Series Description of the target input DICOM in the specified field. Multiple target input SeriesDescriptions can be specified by adding new lines to the config file for matching multiple descriptions. Any series that contains the listed series description configured here will automatically be sent through to the assigned module for processing.

Note, *Modality = CT* and *Orientation = Axial* must still be satisfied when the classifier bypass is enabled, in order for the input DICOMs to be processed.

Outgoing PACS Settings

If using the DICOM protocol, after successful execution of any module, the StrokeSENS application will output results in the form of DICOM secondary captures images and one non-DICOM text file with JSON format content. At installation, the site admin is required to enter the **Outgoing Server AETitle**, **Outgoing Server Port**, and **Outgoing Server Address**. All DICOM image results will be sent to these configured settings. Additionally, by default the non-DICOM output location is "/var/opt/strokesens/output", but this setting may be changed if desired in custom installation.

The outgoing PACS and non-DICOM output path settings are all stored in the config file under the **outgoingPacs** and **nonDicomOutput** headings, respectively, as seen below.

```
[nonDicomOutput]
NonDicomOutputPath=/var/opt/strokesens/output

[outgoingPacs]
ExportDicomNodes\1\retryInitialInterval=30
ExportDicomNodes\1\retryMaxRetries=3
ExportDicomNodes\1\retryMultiplier=2
ExportDicomNodes\1\Address=127.0.0.1
ExportDicomNodes\1\AeTitle=pacs_out
ExportDicomNodes\1\SendAnonymized=false
ExportDicomNodes\1\Port=10400
ExportDicomNodes\1\Description=PACsNode
ExportDicomNodes\1\Timeout=30
ExportDicomNodes\1\ConnectAsAeTitle=strokesens
ExportDicomNodes\1\CharacterEncoding=Unicode
```

These are the supplemental settings for outgoing PACS that the site admin may configure at any time. It is important to note that for changes to take effect the StrokeSENS service will have to be restarted.

retryInitialInterval default is 30 seconds, which is the initial time the application entity will wait when reattempting to export to outgoing PACS on a failure. Adjust when initial wait time is to be increased or decreased.

retryMaxRetries default is 3, allowing application entity to reattempt export to outgoing PACS three times when there is a failure. Adjust when increasing or decreasing retry limit.

retryMultiplier default is 2, this multiplier will be applied on successive retry wait times after the initial retry. Adjust when a bigger or smaller multiplier is to be applied.

SendAnonymized default is false, meaning DICOM outputs will not be anonymized when connecting to outgoing PACS. Change to true if resultant DICOM outputs should be anonymized when connecting to outgoing PACS.

Description default is PACsNode. Change when a new description is to be assigned to the outgoing PACS.

Timeout default is 30, allowing for 30 seconds of wait time for a response before an error is raised. Adjust if outgoing PACS needs to wait longer or shorter for a response.

ConnectAsAeTitle default is strokesens, which is the name the application entity will use when connecting to outgoing PACS. Change when new AE title should be provided to outgoing PACS when connecting.

CharacterEncoding default is Unicode. Adjust if outgoing PACS will be using a different encoding to communicate with the application entity.

8. REST API Descriptions

GET /status
Example URL: http://127.0.0.1:8082/aieng/status
Call this endpoint to get the status of the StrokeSENS application. When StrokeSENS is running and not presently processing any studies the status state will be "idle". When StrokeSENS is running and presently processing a study then the status state will be "processing".

Expected Response:
- Status code: 200, Content: {"status": "idle"}
- Status code: 200, Content: {"status": "processing"}
- Status code: 500, Content: {"status": "error"}

POST /process
Example URL: http://127.0.0.1:8082/aieng/process
Call this endpoint to trigger the processing of a study.

Expected request body: JSON format with the following mandatory keys
- "input_dir" string (required) : The local directory from which the input should be read
- "output_dir" string (required) : The local directory to store outputs
- "done_callback_url" string (required) : The URL to send process completion updates
Example request body:

```
{
        "input_dir": "C:/dir/to/input/dicom",
        "output_dir": "C:/dir/to/output/dicom",
        "done_callback_url": "http://127.0.0.1:8099/done/<request_id>"
}
```

Example of a POST /process request body to StrokeSENS

Expected responses:
- Status code: 200
- Status code: 400, Content: {"error_message" : "…"}
- Status code: 500, Content: {"error_message" : "…"}

Expected request body of callback reply: Called when study is done processing, on both success and failure
- "run_success" bool (required) : true when study processing is successful, false when not

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- "result" dict (required) : contains non-DICOM processing results
- "output_files" string list (required) : contains all output file paths relative to the output_dir received in /process
- "error_message" string (optional)
- "error_code" string (optional)

Example request body:

```json
{
  "output_files": [
    "ASPECTS-contours-IM-0002.dcm",
    "ASPECTS-contours-IM-0003.dcm",
    "ASPECTS-contours-IM-0029.dcm",
        .
    "ASPECTS-contours-IM-0030.dcm",
    "1.2.276.0.7230010.3.1.2.3460997744.5648.1574723012.53419_2024-01-15-12-57-41_ASPECTS.json"
  ],
  "result": {
    "ASPECTS": {
      "ProcessingStatus": {
        "AccessionNumber": "3866040791192985",
        "NumberOfImagesProcessed": "28",
        "OriginalSeriesInstanceUID": "1.2.276.0.7230010.3.1.4.3460997744.5648.1574723012.53432",
        "OriginalStudyInstanceUID": "1.2.276.0.7230010.3.1.2.3460997744.5648.1574723012.53419",
        "PatientName": "RSNA_01_031*",
        "ProcessingTime": "30",
        "Title": "StrokeSENS ASPECTS processing completed"
      },
      "Results": {
        "ASPECTS_Regions": "0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0",
        "ASPECTS_Score": "6"
      },
      "Software": {
        "Address": "Suite 1800, 707 8 Ave SW Calgary, Alberta Canada T2P 1H5",
        "Documentation": "https://www.circlenvi.com/documentation.html",
        "ExpiryDate": "2024-11-07",
        "Manufacturer": "Circle Cardiovascular Imaging Inc.",
        "ManufacturerModelName": "StrokeSENS",
        "SoftwareVersion": "2.2.0_(-1)",
        "SupportEmail": "support@circlecvi.com",
        "UDI": "(01)00882916001025(10)SSXX02Y02Z00B0-1"
      },
      "TimeStamp": "2024-01-15-12-57-41",
      "UnexpectedInputParameters": {}
    },
  },
  "run_success": true
}
```

Example POST request body to the integrating partner's callback URL from StrokeSENS

POST /modifyaspects
Example URL: http://127.0.0.1:8082/aieng/modifyaspects
Call this endpoint to trigger the modification or verification of the Auto-Generated ASPECTS results.

Expected request body: JSON format with the following keys
- "affected_side" int (required) : 0 for left side, 1 for right side, 2 for none
- "aspects_regions" bool vector of size 10 (required) : Represents whether the following 10 regions are affected by the ischemia or not:
  1. M1
  2. M2
  3. M3
  4. M3
  5. M5
  6. M6
  7. Caudate
  8. Lentiform
  9. Insula
  10. Internal Capsule

- "dicom_header_info" JSON string (required) : DICOM header information from any of the slices in the auto-generated DICOM series which contains the following DICOM tags:
  1. Patient's Name
  2. Patient ID
  3. Issuer of Patient ID
  4. Type of Patient ID
  5. Patient's Birth Date
  6. Patient's Sex
  7. Other Patient IDs
  8. Study Date
  9. Study Time
  10. Accession Number
  11. Referring Physician's Name
  12. Study Description
  13. Study Instance UID
  14. Study ID
  15. Series Instance UID
  16. Series Number
  17. Series Description
  18. Institution Name
  19. Station Name
  20. Modality
  21. Instance Number
  22. Pixel Spacing
  23. Image Orientation (Patient)
  24. Image Position (Patient)
  25. Rows
  26. Columns
  27. Referenced Series Sequence

  a. Series Instance UID
  b. Referenced Instance Sequence
     i. Referenced SOP Class UID
     ii. Referenced SOP Instance UID

- "is_modified" bool (required) : true when ASPECTS Score is modified, and false when it is only verified and not modified
- "output_dir" string (required if not exporting DICOMS through DICOM protocol) : The local directory to store outputs
- "done_callback_url" string (required if not exporting DICOMS through DICOM protocol) : The URL to send process completion updates

Example request body:

```
{
  "affected_side": 1,
  "aspects_regions": [
    true,
    true,
    true,
    false,
    false,
    false,
    false,
    false,
    false,
    false
  ],
  "dicom_header_info": "{\"accession_number\":\"3866040791192985\",\"algorithm_version\":\"2.1.0\",\"columns\":\"\",\"image_orientation_patient\":\"1.000000\\\\0.000000\\\\0.000000\\\\0.000000\\\\0.974370\\\\-0.224951\",\"image_position_patient\":\"-119.800\\\\-117.696\\\\-152.328\",\"instance_number\":\"\",\"institution_name\":\"\",\"issuer_of_patient_id\":\"\",\"modality\":\"CT\",\"other_patient_ids\":\"\",\"patient_birth_date\":\"19340927\",\"patient_id\":\"PRoVe-IT-01-031 \",\"patient_name\":\"RSNA_01_031*\",\"patient_sex\":\"F \",\"pixel_spacing\":\"\",\"referenced_series_instance_uid\":\"1.2.276.0.7230010.3.1.4.3460997744.5648.1574723012.53432\",\"referenced_sop_class_uid\":\"1.2.840.10008.5.1.4.1.1.2\",\"referenced_sop_instance_uid\":\"1.2.826.0.1.3680043.9.2842.6478565395777481984008742907750966353\",\"referring_physician_name\":\"\",\"rows\":\"\",\"series_description\":\"\",\"series_instance_uid\":\"1.3.6.1.4.1.53684.2.18122023178546.193532162435612775429614476 39\",\"series_number\":\"2 \",\"software_version\":\"2.1.0_(-1)\",\"sop_class_uid\":\"1.2.840.10008.5.1.4.1.1.2\",\"station_name\":\"\",\"study_date\":\"20120730\",\"study_description\":\"CT ANGIO HEAD/NECK-HEAD \",\"study_id\":\"\",\"study_instance_uid\":\"1.2.276.0.7230010.3.1.2.3460997744.5648.1574723012.53419\",\"study_time\":\"191649.000\",\"type_of_patient_id\":\"\"}",
  "is_modified": true,
  "output_dir": "C:/dir/to/output/dicom",
  "done_callback_url": "http://127.0.0.1:8099/done/<request_id>"
}
```

Example POST /modifyaspects request body to StrokeSENS

9. Logging

The log files contain information on the StrokeSENS threads for DICOM import/exporting, Rest API, licensing, study processing, and general configuration settings for the current execution. Default logging will show Info, Warning, and Error severity logs to provide information to the user of major operational events.

Each time the application starts, a new log file will be created with a timestamped name. Every 24 hours of consecutive running the application will create a new log file and switch all logging for the current execution to there.

Logs sequences from common workflows have been included below. Specific log lines may change build to build and may not be identical to this document.

Startup:

Configured paths and feature timing parameters for the current execution, Licensing activation, basic DICOM import/export node registration, API startup and any series description strings to guarantee processing are logged here.

```
2024-03-26 14-59-11.378 [Info]  (main)           Configuration File Location: /etc/opt/strokesens/config.ini
2024-03-26 14-59-11.379 [Info]  (main)           Log file rotation frequency (mins): 1440
2024-03-26 14-59-11.438 [Info]  (main)           Starting AIENG
2024-03-26 14-59-11.449 [Info]  (CoreApp)        Temporary folder location: /var/opt/strokesens/temp
2024-03-26 14-59-11.449 [Info]  (CoreApp)        Log folder location: /var/opt/strokesens/log
2024-03-26 14-59-11.452 [Info]  (Licensing)      License Directory: /var/opt/strokesens/licenses
2024-03-26 14-59-11.561 [Info]  (Licensing)      Valid active license file found in license directory.
2024-03-26 14-59-11.643 [Info]  (Licensing)      strokesens-lvo module is available in this installation.
2024-03-26 14-59-11.673 [Info]  (Licensing)      strokesens-aspects module is available in this installation.
2024-03-26 14-59-11.702 [Info]  (Licensing)      strokesens-mctap module is available in this installation.
2024-03-26 14-59-11.852 [Info]  (MainService)    Starting StrokeSENS Gateway service with the arguments:
2024-03-26 14-59-11.852 [Info]  (MainService)    --port 8082
2024-03-26 14-59-11.853 [Info]  (MainService)    --aiengport 49697
2024-03-26 14-59-11.853 [Info]  (MainService)    --callbackRetries 3
2024-03-26 14-59-11.864 [Info]  (DicomManager)   NonDicomOutputPath set as: /var/opt/strokesens/output
2024-03-26 14-59-11.865 [Info]  (DicomManager)   SUCCESS Register remote PACS node StoreSCP.1 (pacs_out) on address: 10.1.32.7:10400
2024-03-26 14-59-11.875 [Info]  (MainService)    IncomingStudyDataWaitTimeSecs set as: 20
2024-03-26 14-59-11.875 [Info]  (MainService)    ShortTermStudyStorageTimeMins set as: 5
2024-03-26 14-59-11.877 [Info]  (Classify)       ClassifierBypass series description string for LVO/ClassifierBypass/:
2024-03-26 14-59-11.879 [Info]  (Classify)       ClassifierBypass series description string for ASPECTS/ClassifierBypass/:
2024-03-26 14-59-11.976 [Info]  (MainService)    StrokeSENS Gateway process started
2024-03-26 14-59-11.978 [Info]  (CommManager)    Tcp Server started!
2024-03-26 14-59-11.978 [Info]  (DicomManager)   SCP listener started on local address 127.0.0.1, port 2104, AE title: StrokeSENS
2024-03-26 14-59-12.134 [Info]  (REST API)       Info: strokesens_gateway Start
2024-03-26 14-59-12.135 [Info]  (REST API)       Info: Starting StrokeSENS Gateway 2.1.0 (0) web service in terminal.
2024-03-26 14-59-12.200 [Info]  (REST API)       Info: Working Directory: /opt/strokesens
```
StrokeSENS startup logs

REST API

Logs pertaining to the REST API Service are labelled with the "REST API" heading, as shown below. All API requests to StrokeSENS are logged.

```
2024-03-26 14-59-12.134 [Info]  (REST API)       Info: strokesens_gateway Start
2024-03-26 14-59-12.135 [Info]  (REST API)       Info: Starting StrokeSENS Gateway 2.1.0 (0) web service in terminal.
2024-03-26 14-59-12.200 [Info]  (REST API)       Info: Working Directory: /opt/strokesens
2024-03-26 14-59-30.944 [Info]  (REST API)       Info: Received POST /process request.
```

Licensing:

The license activation of a valid StrokeSENS activation key is logged during startup. The directory where the license files are to be found, as well as available modules are logged.

```
2024-03-26 14-59-11.452 [Info]  (Licensing)          License Directory: /var/opt/strokesens/licenses
2024-03-26 14-59-11.561 [Info]  (Licensing)          License activation successful 1234-5678-8765-4321.
2024-03-26 14-59-11.643 [Info]  (Licensing)          strokesens-lvo module is available in this installation.
2024-03-26 14-59-11.673 [Info]  (Licensing)          strokesens-aspects module is available in this installation.
```

If valid license files are found in the provided directory, from either a previous activation or by placing offline license files, then the existence of valid license files will be logged.

```
2024-03-26 14-59-11.452 [Info]  (Licensing)          License Directory: /var/opt/strokesens/licenses
2024-03-26 14-59-11.561 [Info]  (Licensing)          Valid active license file found in license directory.
2024-03-26 14-59-11.643 [Info]  (Licensing)          strokesens-lvo module is available in this installation.
2024-03-26 14-59-11.673 [Info]  (Licensing)          strokesens-aspects module is available in this installation.
```

In the case where no activation key is provided, and no valid license files exist in the specified directory, the following error message will appear. It will provide the directory where the offline request form will be found.

```
2024-03-26 20-06-42.994 [Info]  (main)         Configuration File Location: /etc/opt/strokesens/config.ini
2024-03-26 20-06-42.994 [Info]  (main)         Log file rotation frequency (mins): 1440
2024-03-26 20-06-42.995 [Info]  (main)         Starting AIENG
2024-03-26 20-06-42.998 [Info]  (CoreApp)      Temporary folder location: /var/opt/strokesens/temp
2024-03-26 20-06-42.999 [Info]  (CoreApp)      Log folder location: /var/opt/strokesens/log
2024-03-26 20-06-43.001 [Info]  (Licensing)    License Directory: /var/opt/strokesens/licenses
2024-03-26 20-06-43.012 [Error] (Licensing)    ***
2024-03-26 20-06-43.012 [Error] (Licensing)    No active license file or activation key found.
2024-03-26 20-06-43.012 [Error] (Licensing)    Please enter an activation key in the configuration file and restart the StrokeSENS service for online activation.
2024-03-26 20-06-43.012 [Error] (Licensing)    Alternatively, please contact support@circlenvi.com with the generated request for an offline license or assistance.
2024-03-26 20-06-43.012 [Error] (Licensing)    ***
2024-03-26 20-06-43.018 [Info]  (Licensing)    Generated license request file: \_StrokeSENS_2.1.0_(298)_2024-03-26.req
2024-03-26 20-06-43.019 [Warn]  (CoreApp)      Please license with activation key or offline license and restart StrokeSENS.AIEngine to enable services.
```

Importing:

Imported images will be noted every time they are received, this may be logged in multiple lines, and not always all related to a single study.

Once the **IncomingStudyDataWaitTimeSecs** time is complete without any new images for a given study, that study will be added to the ML service queue and processed when scheduled.

```
2024-03-26 19-52-51.762 [Info]  (DicomImport)    Importing 28 stored PACS images done
2024-03-26 19-52-51.763 [Info]  (MainService)    Imported api study request for study ID 1.2.840.113970.3.19.1.17554001.20151006.1151525 and Gateway Id 1
2024-03-26 19-52-51.763 [Info]  (MainService)    Starting worker for study ID 1.2.840.113970.3.19.1.17554001.20151006.1151525
2024-03-26 19-52-51.763 [Info]  (ImportWorker)   Incoming study data wait time seconds configured to 20
2024-03-26 19-52-51.764 [Info]  (ImportWorker)   Short term study storage time mins configured to 5
```

Processing:

Classification of series in study and runtime of StrokeSENS modules are logged, as seen below.

```
2024-03-26 19-53-16.776 [Info]  (MLService)      Start Processing ML for study ID 1.2.840.113970.3.19.1.17554001.20151006.1151525
2024-03-26 19-53-16.883 [Info]  (Classify)       Series 1.2.840.113619.2.334.3.2550825344.743.1444107434.120 classified for ASPECTS algorithm via series description
2024-03-26 19-53-16.883 [Info]  (StudyService)   studyUID-1.2.840.113970.3.19.1.17554001.20151006.1151525 seriesUID-1.2.840.113619.2.334.3.2550825344.743.1444107434.120 category-NCCT images-27 seriesNum
2024-03-26 19-53-16.888 [Info]  (Classify)       NCCT series for ASPECTS processing: 1.2.840.113619.2.334.3.2550825344.743.1444107434.120 for study ID 1.2.840.113970.3.19.1.17554001.20151006.1151525
2024-03-26 19-53-16.888 [Info]  (Classify)       NCCT series for mCTAp processing: 1.2.840.113619.2.334.3.2550825344.743.1444107434.120 for study ID 1.2.840.113970.3.19.1.17554001.20151006.1151525
2024-03-26 19-53-16.980 [Info]  (MLService)      Number of images passed to ASPECTS Lib: 27 for study ID 1.2.840.113970.3.19.1.17554001.20151006.1151525
2024-03-26 19-54-10.869 [Info]  (MLService)      Aspects elapsed time: 53s for study ID 1.2.840.113970.3.19.1.17554001.20151006.1151525
2024-03-26 19-54-10.869 [Info]  (MLService)      Finished processing ASPECTS ML for study ID 1.2.840.113970.3.19.1.17554001.20151006.1151525; Aspects Score: 6
2024-03-26 19-54-10.870 [Info]  (MLService)      Affected regions status: 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0, 0, 1, 0 for study ID 1.2.840.113970.3.19.1.17554001.20151006.1151525
2024-03-26 19-54-10.871 [Info]  (MLService)      Created aspects json file for study ID 1.2.840.113970.3.19.1.17554001.20151006.1151525
```

Exporting:

The non-DICOM and DICOM output exporting status is logged at this stage. If all exports are successful, the application cleans up all temp files immediately after the **ShortTermStudyStorageTimeMins** time is complete.

```
2024-03-26 19-54-11.010 [Info]  (REST API)         Info: Study progress update response run success: true
2024-03-26 19-54-11.010 [Info]  (REST API)         Info: Sending study processing complete to callback url: http://127.0.0.1:8099/done
```

10. General troubleshooting

Service does not start?

Ensure proper licensing is in place and running correctly, confirmed through the logs.

Ensure the config.ini file is in the correct location.

LogDirectory and TempDirectory are mandatory paths in the config.ini file.

Docker container does not run?

Ensure that no existing containers, or other applications are using the ports the Docker container is trying to publish on through the -p option.

Ensure all local -v paths mounted to the container exist, and if mounting an external config.ini file that the file is in the correct location.

11. Additional documentation

In addition to the StrokeSENS software, a package of accompanying documentation is also provided. The documentation package includes the following documents:

- User Manual
- DICOM Conformance Statement
- Release Notes
- Software Usage Terms & Conditions

12.Support

For technical questions please contact our team by phone or e-mail:

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