

CT Pneumonia Analysis

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CT Pneumonia Analysis

In the following sections, you find procedural information and background information on the *syngo.via* CT Pneumonia Analysis prototype.

Please note that the *syngo.via* CT Pneumonia Analysis prototype is not intended for clinical use.

CT Pneumonia Analysis automatically identifies and quantifies hyperdense areas of the lung. It enables you to quickly analyze your scans for research purposes.

The CT Pneumonia Analysis prototype performs automated lung opacity analysis on axial CT data with slice thicknesses up to 5 mm. As results, you will get MPR series containing segmentations of the high opacity abnormalities and of the lungs as well as a table with various measurements, e.g. the relative (“percentage of opacities”) and absolute volume of the lungs affected by opacities.

In addition, you can compare the mean and standard deviation of HU values between lung parenchyma and the detected opacities. All quantitative results are also presented separately for the left and right lung as well as per lung lobe. The Volume Rendering (VRT) allows a quick overview of the spatial distribution of the opacities.

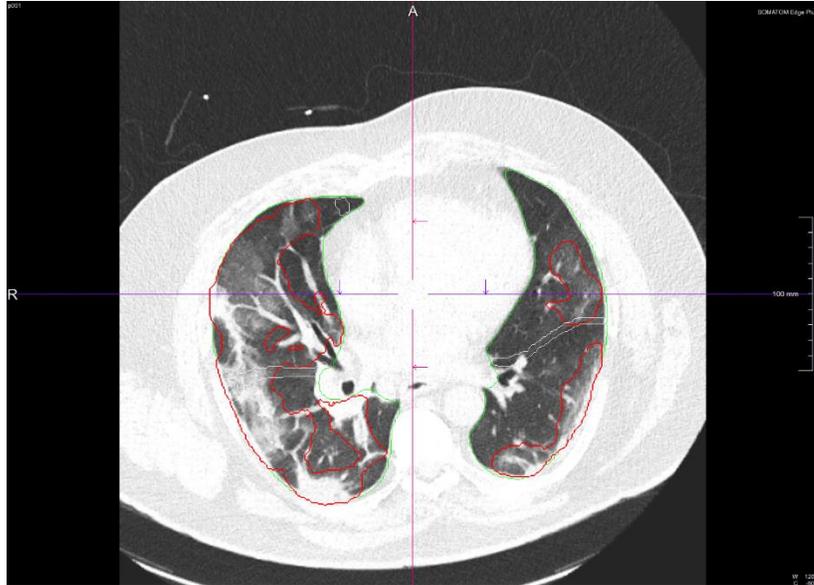
If you want to add new or alter automatic opacity segmentations, the prototype provides you an intuitive nudge editing tool.

The table of quantitative results and a stack of axial slices highlighting the opacities can be exported to your *syngo.via* system.

Algorithm for Detection and Quantification of High Opacity Abnormalities

As input, a non-contrasted Chest CT is taken. An AI algorithm automatically detects and quantifies abnormal tomographic patterns commonly present in lung infections, namely Ground Glass Opacities (GGO) and consolidations.

Based on 3D segmentations of lesions, lungs, and lobes, the algorithm quantifies the extent of overall abnormalities and the presence of high opacity abnormalities both globally and lobe-wise.



The algorithm can roughly be outlined as follows:

- 1.) Automatic computation of the lung and lobe segmentation mask
- 2.) Abnormality segmentation

The algorithm has been first trained on a large cohort of patients with various diseases, then fine-tuned with a cohort with abnormal patterns including ground glass opacities, consolidation, effusions, and masses, to improve the robustness of the lung segmentation over the infected areas.

Data Requirements

The algorithm is not optimized for pediatric patients. The minimum patient age is 18 years.

The prototype only accepts CT data as input. The data must ideally contain a full lung ranging from the apex to the lung base. Partial lung data can be technically processed but might lead to inferior results.

In general, the image quality of the lesion detection and quantification algorithms depends on characteristics of the original CT dataset such as spatial resolution, noise, artifacts and others. For a good spatial resolution, it is recommended to use thin axial reconstructions (e.g. slice thickness below 1.5mm). Technically

data up to 5mm slice thickness can be processed with possible deterioration of the quality of the results.

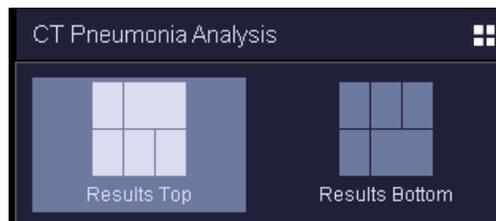
User Interface

Start the Calculation

After starting the prototype, the algorithm for detection and quantification of abnormalities starts automatically. It will take up to 1-2 minutes to process data and to calculate all results. While running the algorithm, you can scroll through the different MPR series.

Layouts and Visualization

After calculation time, the results are automatically shown. To switch between the available layouts, press the Layouts button:

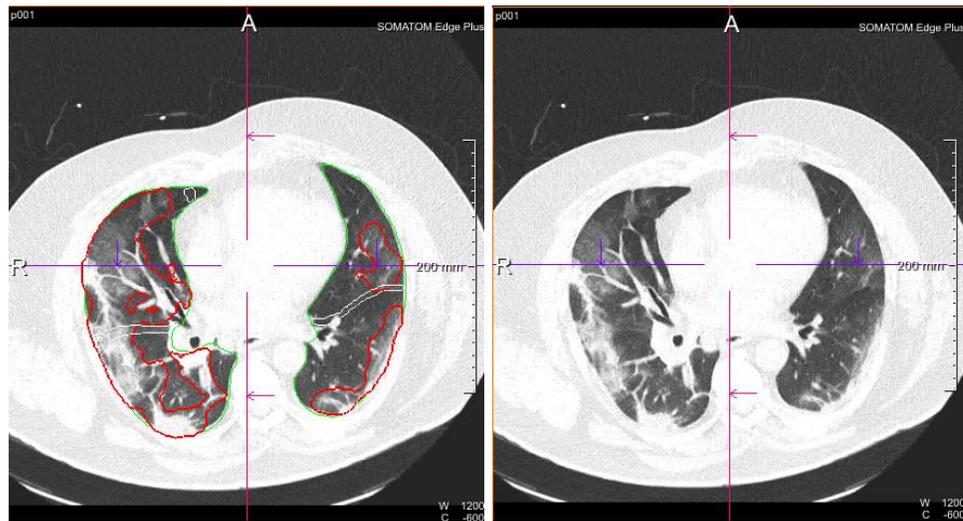
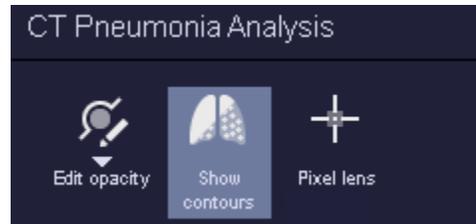


Accordingly, the layouts will show the respective MPR views with lung and abnormalities segmentation. The segmentation results of the lung are shown in green and the segmentation results of lung opacities are shown with red borders. The VRT allows a quick overview of the spatial distribution of the opacities. In addition, a summary table of quantitative results is presented:

The screenshot displays the main interface of the CT Pneumonia Analysis software. On the left is a sidebar with navigation options like 'Exit', 'Home', 'Results', 'Lung Tools', and 'Download CSV'. The central area shows a 3D VRT of a lung with red and green segments. To the right is a table of quantitative results. Below the VRT are two 2D MPR views (Axial and Coronal) and a small 3D VRT of the segmented lung.

		Total Opacity Score: 10					
		Percentage of opacity: 30.97					
LR	Labels	Both lungs	Left upper lobe	Left lower lobe	Right upper lobe	Right middle lobe	Right lower lobe
Affected	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Opacity Score	10	2	1	3	2	2	2
Lung volume (ml)		3940.90	1038.51	934.06	765.17	345.27	857.31
Volume of opacity (ml)		1220.68	284.27	79.88	435.89	128.80	291.84
Percentage of opacity (%)		30.97	27.37	8.55	56.97	37.30	34.04
Volume of high opacity (ml)		228.45	22.08	13.30	88.00	13.86	91.23
Percentage of high opacity (%)		5.80	2.13	1.42	11.50	4.91	10.54
Mean HU total		-857.45	-713.38	-712.18	-583.98	-689.48	-578.67
Mean HU of opacity		-486.45	-598.39	-476.68	-464.73	-552.34	-383.47
Standard deviation total		262.58	220.84	230.79	278.80	238.91	296.68
Standard deviation of opacity		268.13	222.07	246.05	266.40	238.00	281.65

In the upper left corner, you can switch the lung and abnormalities contour visualization on and off.



Interactions and Mouse Events

The reference lines of other MPR segments can be dragged with the left mouse button to the desired position.

Within the MPR segments, the user can go through a stack of CT slices using the mouse wheel or the right mouse button.

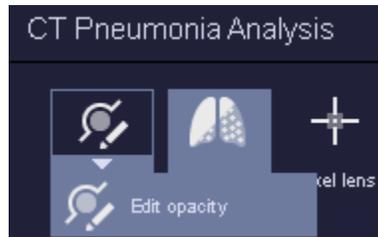
The windowing of the displayed images is controlled by pressing the mouse wheel: up-down for center and left-right for width.

Furthermore, a Pixel Lens tool is provided for interactive inspection of HU values



Contour Editing

If you want to modify automatic delineation of suspected infection areas, you can either edit an existing opacity segmentation or add a new one by using the below functionalities.



<p>Nudge</p>	<p><i>Edit opacity:</i> starting inside the current object, brushing outwards, adds voxels to the current object. Respectively, starting outside and brushing inwards, deletes voxels from the current object.</p>
	<p><i>Add Opacity:</i> explicitly add voxels. Useful to draw a new object from scratch.</p>

General Tools

In the lower left corner of the user interface, the following tools are provided:



- “Help” to open the user manual.
- “Reset” to reset the windowing to lung window (1200, -600) automatically.
- “Text Visibility” to hide/show text in the segments.
- “Reflines Visibility” to hide/show the reference lines.

Quantitative Results

Statistics

The following statistics are calculated:

- Affected (yes/no):
“yes”, if algorithm detects high opacity abnormalities in the given part of the lung, “no” otherwise
- Opacity score
 - % of opacity within a given region = 0: Score = 0
 - % of opacity within a given region ≤ 25 : Score = 1
 - % of opacity within a given region ≤ 50 : Score = 2
 - % of opacity within a given region ≤ 75 : Score = 3
 - % of opacity within a given region > 75 : Score = 4

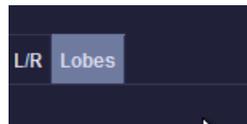
This score will be calculated for each lobe. For left/right lung the opacity score is the sum of the respective lobes and for the total opacity score all lobe values are summed up.

- Lung volume (ml)
- Volume of opacity as absolute value of lung parenchyma affected by infection (ml)
- Percentage of opacity within a given lung region (%)
- Volume of high opacities as absolute value (ml) (high opacity regions, i.e. it is a subset of overall opacity)
- Percentage of high opacities within a given lung region (%)
- Mean HU total (of all parenchyma within a given lung region) (HU)
- Mean HU of opacity within a given lung region (HU)
- Standard deviation HU total (of all parenchyma within a given lung region) (HU)
- Standard deviation HU of opacity within a given lung region (HU)

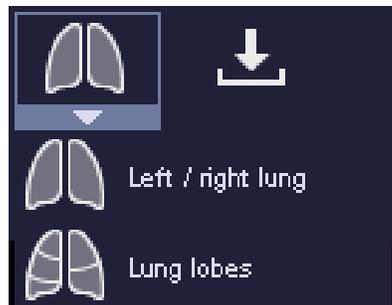
All statistics are calculated for the whole lung, left lung, right lung and per lung lobe, respectively.

		Total Opacity Score: 10		Percentage of opacity: 30.97			
L/R	Lobes	Both lungs	Left upper lobe	Left lower lobe	Right upper lobe	Right middle lobe	Right lower lobe
Affected	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Opacity Score	10	2	1	3	2	2	2
Lung volume (ml)	3940.90	1038.51	934.66	765.17	345.27	857.31	
Volume of opacity (ml)	1220.68	284.27	79.88	435.89	128.80	291.84	
Percentage of opacity	30.97	27.37	8.55	56.97	37.30	34.04	
Volume of high opacity (ml)	228.46	22.08	13.30	88.00	13.86	91.23	
Percentage of high opacity	5.80	2.13	1.42	11.50	4.01	10.64	
Mean HU total	-657.45	-713.38	-712.18	-583.98	-699.48	-578.67	
Mean HU of opacity	-486.45	-598.39	-476.68	-464.73	-552.34	-383.47	
Standard deviation total	262.58	220.84	230.79	279.80	239.61	296.68	
Standard deviation of opacity	268.13	222.07	246.06	266.40	239.50	281.65	

The user can choose between left/right lung-based results and the lung lobe-based results by selecting the respective tab in the result table



or by switching via the button in the upper left menu.



Export of Numerical Results

All numerical results can be exported to a comma separated file (csv) by using the button “Download CSV”.



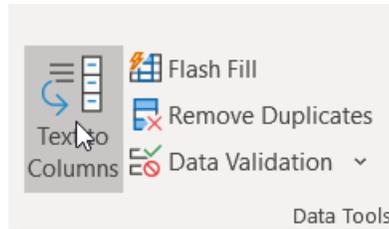
Note: for the export international settings for numbers are used (“.” as decimal separator). This will work for most of the countries. In countries using “,” as decimal separator (e.g. in Germany) dedicated spreadsheet settings need to be adjusted on import.

If you use Microsoft Excel, you can

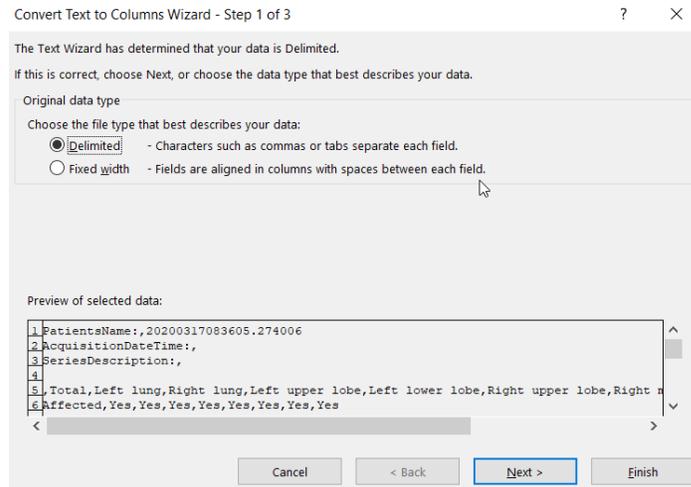
- *Open .csv file with Excel*
- *Select first column (it will contain all data)*

	A	B	C	D	E	F
1	PatientsName:,20200317083605.274006					
2	AcquisitionDateTime:,					
3	SeriesDescription:,					
4						
5	,Total,Left lung,Right lung,Left upper lobe,Left lower lobe,Rig					
6	Affected,Yes,Yes,Yes,Yes,Yes,Yes,Yes,Yes					
7	Lung volume (ml),3210.258409881592,1454.8992805480957					
8	Volume of opacity (ml),1583.8653350830077,602.31262664					
9	Percentage of opacity (ml),49.33762741088867,41.39892196					
10	Volume of consolidation (ml),497.1505187988281,167.4714					
11	Percentage of consolidation,15.486309051513672,11.51086					
12	Infection Score,2,2,3,1,3,2,1,4					
13	HU mean overall,-486.8449243678825,-506.5994297191262					
14	HU mean of opacity,-349.7106127848969,-369.5261042830					
15	HU standard deviation overall,248.92916435257283,236.741					
16	HU standard deviation of opacity,230.02812287627805,222.					
17						

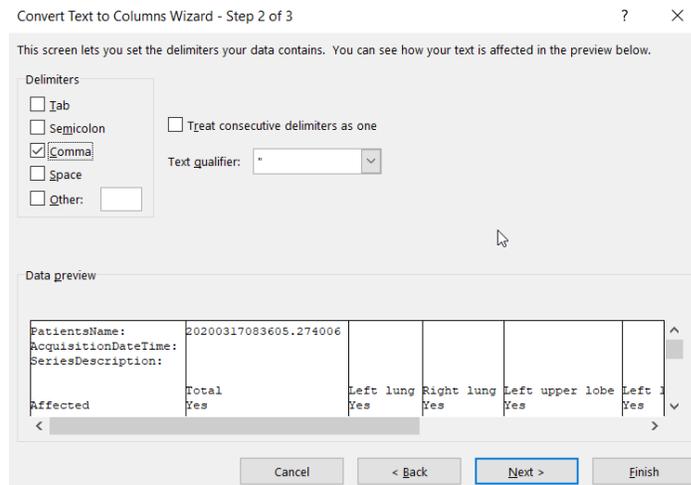
- *Choose Data -> Text in Columns*



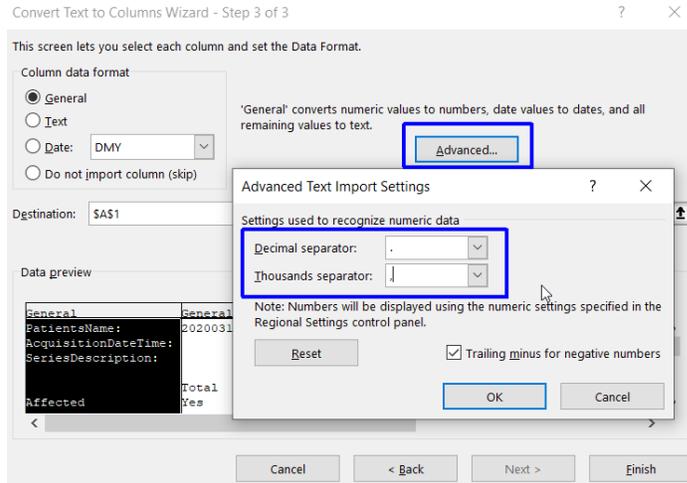
- *Dialog opens. Within the dialog:*
 - *Choose “Delimited” and press “Next”*



- *Choose “comma” as delimiter and press “Next”*



- *Under “Advanced...” settings set “.” as a decimal separator and “,” as 1000’s separator*



- Press “Finish”

Export of Image Results

The CT Pneumonia Analysis prototype allows the user to create and save snapshots. Two possibilities are available:



- “Create Snapshot” creates snapshots of all segments of the current layout. By specifying an output directory on the local machine, the user can save the images locally as PNG-files.
- “Send Results” allows the user to send the results as DICOM data to the *syngo.via* server. The results will appear after CT Pneumonia Analysis has been closed if the user confirms to save the results in the dialog appearing then.