```
//      V 0.1
ver = "p0.1"
//  update: 04.11.2022
//      by: Martin Schätz
//  email: schatzm@vscht.cz
//
// based on V 0.3clean 27.12.2021 Clean version
////////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////////
```

- # General info

```
print("\\Clear");
run("Close All");
print("Version: " + ver + ", last edit 04.11.2022");

//Open files
////////////////////////////


//#@ File (label = "Output directory", style = "directory") output




if ((bTiff & bDICOM) | (bDICOM & bCDICOM) | (bCDICOM & bTiff)) {
        print("\\Clear");
        exit("Only one file type can be selected");
}


openSequenceFolder(input,bCDICOM,bDICOM,bTiff,bSDICOM);

if (bTiff | bDICOM) {
        print("uint16 used");



}

if (lung){
        width=1070; level=-340;
        min = level - width/2;
    max = level + width/2;
    setMinAndMax(min, max);
    print("Lung view, width: " + width + ", level: "+ level);
}
if (bone){
        width=500; level=200;
```

```
        min = level - width/2;
    max = level + width/2;
    setMinAndMax(min, max);
    print("Bone view, width: " + width + ", level: "+ level);
}
```

```
> Version: p0.1, last edit 04.11.2022
> Opening: C:\01_projects\01_COVID_sw_tool\DATA\CT1_2\CT1_2_TIFF\CT1_2_TIFF
> uint16 used
```

- **Processing**

```
// get image name
title=getTitle();
//////////////////////////


start=getTime();
if (!MMp) {
        setBatchMode("show");
}

imgDir = input;
getDateAndTime(year, month, dayOfWeek, dayOfMonth, hour, minute, second, ms
acTime="";
acTime = "" + year + "_" + month + "_" + dayOfMonth + "_" + hour + "_" + mi
print(acTime);

dirArray=split(imgDir, File.separator());
dirName=dirArray[dirArray.length-1];

getDimensions(width, height, channels, slices, frames);
```

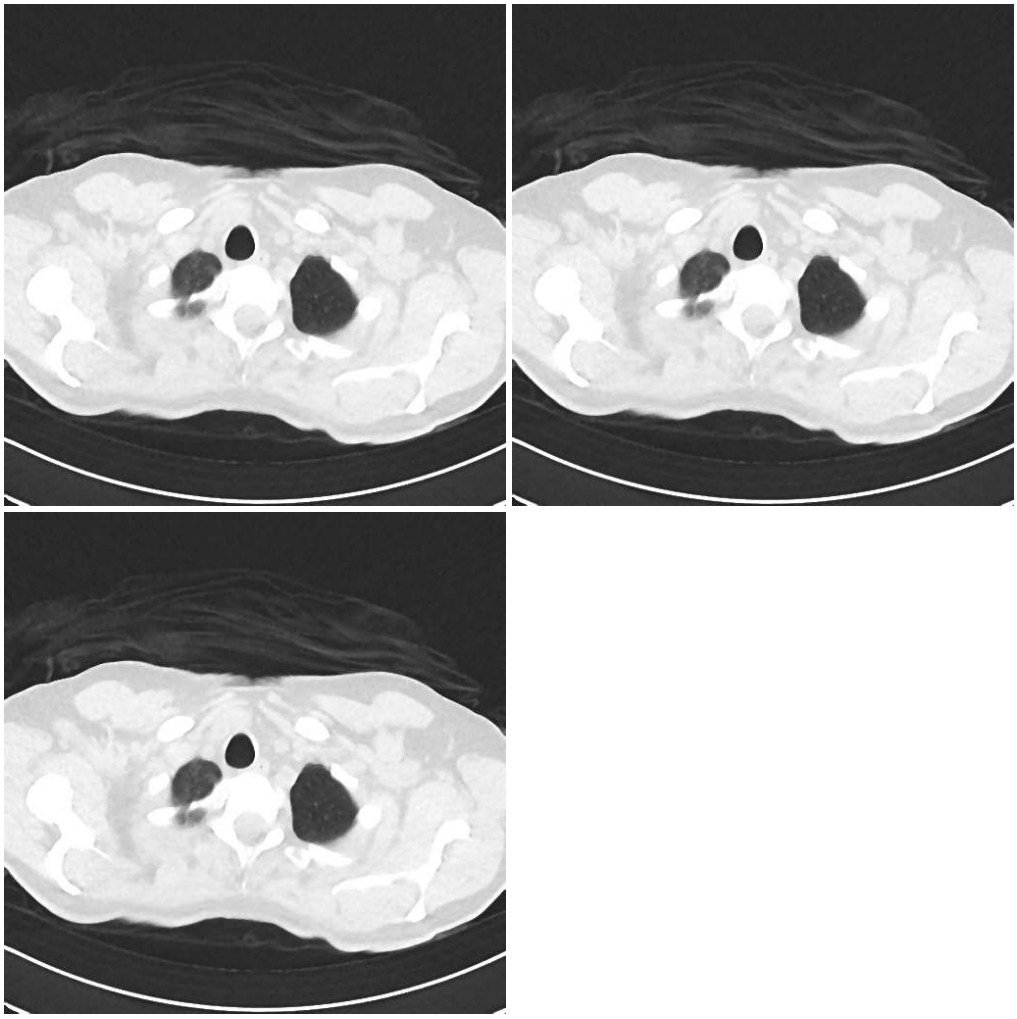
```
> 2022_10_4_16_4
```

- # Lung masking

```
//print("Image path: "+replace(fileDir,title,""));
//select lung parts
waitForUser("Lung selection", "Please find start of lungs in stack");
start=getSliceNumber();
waitForUser("Lung selection", "Please find end of lungs in stack");
end=getSliceNumber();
if (!MMp) {
        setBatchMode(true);
}
print("Start of lungs: "+start);
print("End of lungs: "+end);
run("Duplicate...", "duplicate range="+start+"-"+end);
rename("orig");
selectImage(title);
close(title);
selectImage("orig");

// get voxel size
getVoxelSize(Vwidth, Vheight, Vdepth, Vunit);

// get iamge location
maskDir = imgDir+"masks_"+acTime+File.separator;
if (!File.exists(maskDir))
        File.makeDirectory(maskDir);

print("Image directory: "+imgDir);
saveAs("tiff",maskDir+replace(title,".tiff","")+"_lungs_subpart");
rename("orig");

if (lung){
        width=1070; level=-340;
        min = level - width/2;
    max = level + width/2;
    setMinAndMax(min, max);
    run("Apply LUT", "stack");
}
if (bone){
        width=500; level=200;
        min = level - width/2;
    max = level + width/2;
    setMinAndMax(min, max);
    run("Apply LUT", "stack");
}

// apply median filter
```

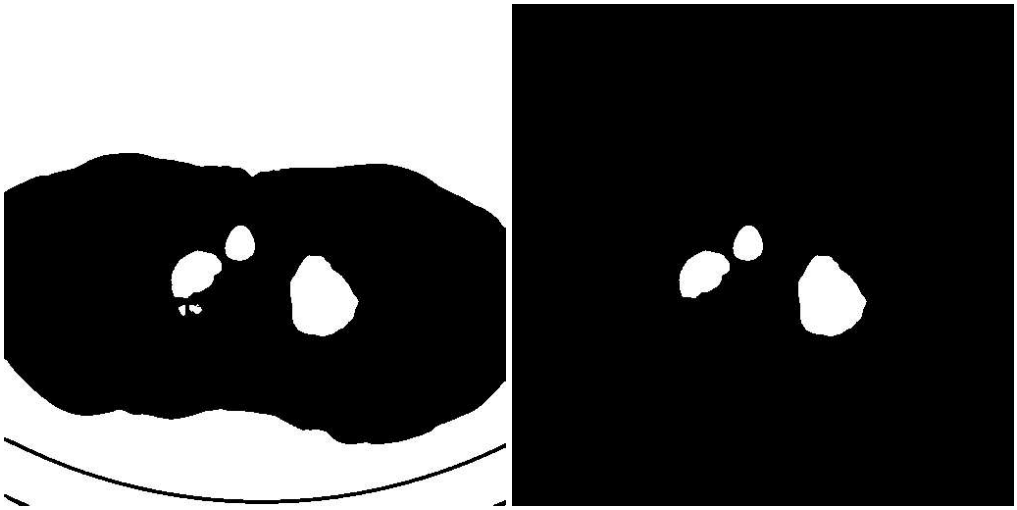
```
run("Median...", "radius=2 stack");
selectImage("orig");

// enhance contrast for better details
//run("Enhance Contrast", "saturated=0.35");
//run("Apply LUT", "stack");

// duplicate stack for lung thresholding
run("Duplicate...", "duplicate");
rename("lungs");

// duplicate stack for covid thresholding
run("Duplicate...", "duplicate");
rename("covid");

//processing
////////////////////////////////////////////
//setBatchMode(false);
selectImage("lungs");
run("Original Scale");

// set same voxel size
setVoxelSize(Vwidth, Vheight, Vdepth, Vunit);

//run("8-bit");
run("Threshold...");
                setAutoThreshold("Default dark");
        getThreshold(lower,upper);
        setThreshold(-1024, lower);
if (!MMp) {
        setBatchMode("show");
}

waitForUser("Setup threshold for all but body");
if (!MMp) {
        setBatchMode("hide");
}

getThreshold(lowerLungs,upperLungs);
```

```
> Start of lungs: 17
> End of lungs: 91
> Image directory: C:\01_projects\01_COVID_sw_tool\DATA\CT1_2\CT1_2_TIFF
```



- **Making lung mask**

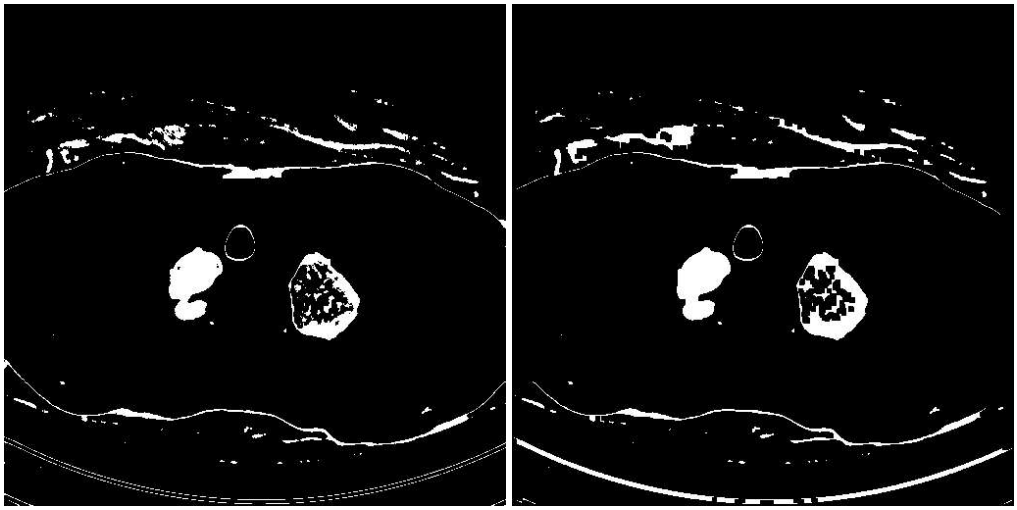
```
run("Convert to Mask", "method=Default background=Light black");

//run("Invert", "stack"); //invert
run("Analyze Particles...", "size=800-Infinity pixel circularity=0.12-1.00
run("Invert LUT");
//run("Invert", "stack"); //invert

run("Dilate", "stack");
run("Dilate", "stack");
run("Fill Holes", "stack");
run("Erode", "stack");
run("Erode", "stack");
//run("Invert", "stack");
run("Convert to Mask", "method=Default background=Light black");

// save mask
saveAs("tiff",maskDir+replace(title,".tiff","")+"_lung_mask");
rename("mask_lungs");
//////////////////////////
```



- **Pneumonia/Covid masking**

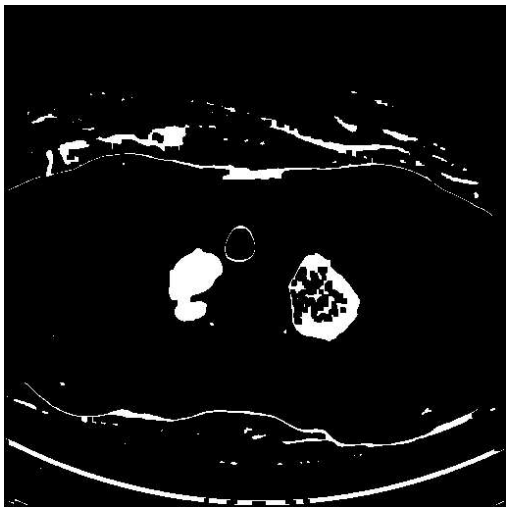
```
selectImage("covid");
run("Original Scale");

// set same voxel size
setVoxelSize(Vwidth, Vheight, Vdepth, Vunit);
//run("8-bit");
run("Threshold...");
                setAutoThreshold("Default dark");
        getThreshold(lower,upper);


//setThreshold(38, 126);
if (!MMp) {
        setBatchMode("show");
}
waitForUser("Setup threshold for Covid");
if (!MMp) {

        setBatchMode("hide");
}
getThreshold(lowerCov,upperCov);
run("Convert to Mask", "method=Default background=Light black");
if (!MMp) {
        setBatchMode(true);
}
run("Analyze Particles...", "size=0-Infinity pixel circularity=0.00-1.00 sh
run("Invert", "stack");

// get rid of small parts //needs to be optimised
run("Dilate", "stack");
run("Dilate", "stack");
run("Erode", "stack");
run("Erode", "stack");

//run("Invert", "stack");
```

```
run("Invert", "stack");
run("Invert LUT");

// save mask
saveAs("tiff",maskDir+replace(title,".tiff","")+"_covid_mask");
rename("mask_covid");
////////////////////////////////
```



- ## Combining Pneumonia/Covid mask and Lung mask

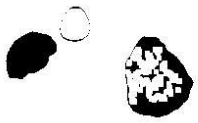
```
//get only information inside of lungs
selectImage("mask_lungs");
run("Original Scale");
selectImage("mask_covid");
setVoxelSize(Vwidth, Vheight, Vdepth, Vunit);
imageCalculator("Multiply create stack", "mask_covid","mask_lungs");
rename("mask_covid_final");
run("Invert LUT");
////////////////////////////////
```



- Get Covid area

```
//get covid area
selectImage("mask_covid_final");
//run("Analyze Particles...", "pixel display exclude clear add stack");
run("Analyze Particles...", "pixel exclude clear add stack");

CareaSum=0;
CIntInt=0;
for (i = 0; i < nResults; i++) {
        if (getResult("Area", i)>-1) {
                CareaSum=CareaSum+getResult("Area", i);
                CIntInt=CIntInt+getResult("RawIntDen", i);
        }
}
print("Covid area: " + CareaSum);

////////////////////////////////
```

```
> Covid area: 2546242
```

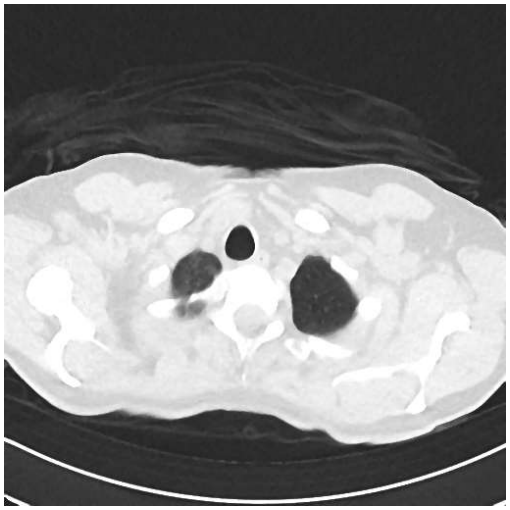
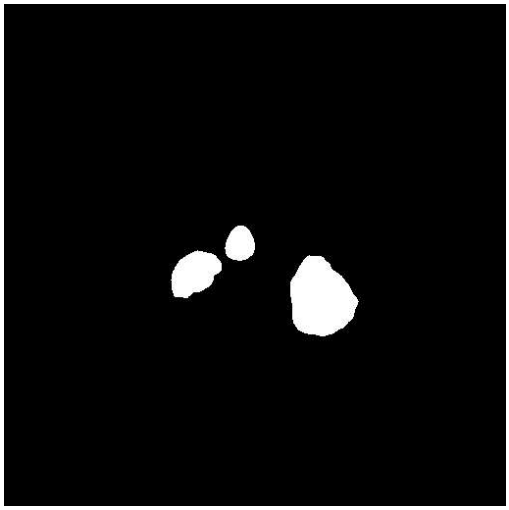


- Get lungs area

```
//get lungs area
selectImage("mask_lungs");
//run("Analyze Particles...", "pixel display exclude clear add stack");
run("Analyze Particles...", "pixel exclude clear add stack");
LareaSum=0;
LIntInt=0;
for (i = 0; i < nResults; i++) {
        if (getResult("Area", i)>-1) {
                LareaSum=LareaSum+getResult("Area", i);
                LIntInt=LIntInt+getResult("RawIntDen", i);
        }
}
print("Lungs area: " + LareaSum);
```

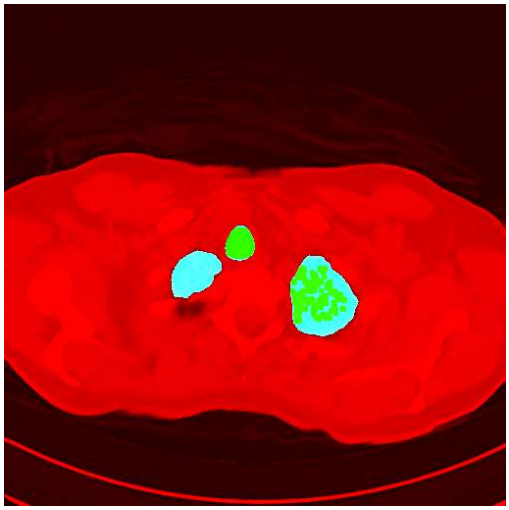
```
selectImage("orig");
// if original data were 16 bit, we need to convert to 8-bit
run("8-bit");
run("Clear Results");
```

```
> Lungs area: 2908376
```

- **Visualization**

```
//make visualization
run("Merge Channels...", "c1=orig c2=mask_lungs c3=mask_covid_final create"
saveAs("tiff",maskDir+replace(title,".tiff","")+"_composite_results.tiff");

close("\\Others");
if (!MMp) {
        setBatchMode("exit and display");
}
////////////////////////////////
```



- **Results**

```
print("Results: ");
print((CareaSum/LareaSum)*100);
print("Lung th:"+lowerLungs+", "+upperLungs);
print("Covid th:"+lowerCov+", "+upperCov);
percentage=(CareaSum/LareaSum)*100;
if (isNaN(percentage)) {
                percentage=0;
        }
if (percentage<0) {
                percentage=0;
        }
print("Voxel size, width: "+Vwidth+", height: "+Vheight+", depth: "+Vdepth+
print(title + " COVID percentage is: " + percentage);
print("A semi-quantitative CT score was calculated based on the extent oflc
print("Score is: " + doScore(percentage));

print("");

print("");


stop=getTime();
print("Time: " + (stop-start)/1000);
selectWindow("Log");
saveAs("Text", imgDir+replace(title,".tiff","")+"_log_"+acTime+".txt");


setBatchMode(false); //always turn off batch mode at the end


////////////////////functions//////////////
//score function
function doScore(percentage) {
        if (isNaN(percentage)) {
                percentage=0;
        }
```

```
        }

        helahtyLungPerc = (0.225+4.46+3.04)/3;
        percentage = percentage - helahtyLungPerc;
        if (percentage<0) {
                percentage=0;
        }

        if (percentage<5) {
                return 1;
        }
        if (percentage>5 && percentage<25) {
                return 2;
        }
        if (percentage>25 && percentage<50) {
                return 3;
        }
        if (percentage>50 && percentage<75) {
                return 4;
        } else {
                return 5;
        }
}

// opening specific version of file
function openSequenceFolder(input,bCDICOM,bDICOM,bTiff,bSDICOM) {
        list = getFileList(input);
        print("Opening: " + input+File.separator+list[0]);
        if (bCDICOM==true) {
                // open compressed DICOM with Bio-Formats Importer
                openCompressDICOMSequence(input+File.separator+list[0], lis
        } else {
                        if (bDICOM==true) {
                                // open DICOM
                                openDICOMSequence(input+File.separator+list
                        } else {
                                        // open TIFF
                                        if (bTiff==true) {
                                                openTiffSequence(input+File
                                        } else {
                                                if (bSDICOM==true) {
                                                        openSiemensDICOM(in
                                                } else {
                                                exit("No sequence type was
                                                }
                                        }
                                }
                        }

        rename(list[0]);
}

function openCompressDICOMSequence(filePath, numImages){
        //run("Bio-Formats Importer", "open=I:/FNKV/dataset_paper2/patient_
        run("Bio-Formats Importer", "open=["+filePath+"] color_mode=Grayscа
```

```
        run("Bio-Formats Importer", "open=["+filePath+"] color_mode=Grayscale
        run("Enhance Contrast", "saturated=0.35");
}
function openDICOMSequence(filePath){
        run("Image Sequence...", "dir=["+filePath+"] sort");}

function openTiffSequence(filePath){
        run("Image Sequence...", "open=["+filePath+"] sort");
}

function openSiemensDICOM(input) {
        list = getFileList(input);
        //list = Array.sort(list);
        setBatchMode(true);
        for (i = 0; i < list.length; i++) {
                open(input + File.separator + list[i]);
        }
        title=getTitle();
        run("Images to Stack", "name="+title+" title=[] use");
        setBatchMode("show");
        setBatchMode(false);
}
```

```
> Results:
> 87.5486
> Lung th:0, 139
> Covid th:68, 196
> Voxel size, width: 1, height: 1, depth: 1, units: pixels
> CT1_2_TIFF0000.tif COVID percentage is: 87.5486
> A semi-quantitative CT score was calculated based on the extent oflobar i
> Score is: 5
>
>
> Time: 1.6676E9
```