

# Management and Visualization of images with labeled segments:

## Chest CT Atlas Management

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Introduction to label map management. Currently the main label map is defined for whole-chest CT images in which case it is called a chest map.

Commands: *vimap vcmmod vlctovtk*

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## Overview

**vimap** manages **label maps** that partition an image into a number of defined objects or "anatomical" regions.

- Example: a chest CT image may contain various organs and structures (chestmap)
  - Lung, airway, bones, heart, vessels, ...

**Label maps** contain the combined results from a number of segmentation algorithms

- Segmentation algorithms identify the region of a single structure or organ
- some segmentation algorithms depend on the results of others.

Available tools:

- **vimap**: Manage a label map file
- **vcmmod**: Create visualizations of a chest map

VisionX-V4 *vimap vcmmod vlctovtk*

## Image Segmentation and region labeling

- Data file types:
  - **CT whole-lung image**: 3D image of the whole chest
    - Pixel format 16-bit integer
    - The original image on which all segmentations are based
  - **Organ Label definitions**: default system file v4/etc/vsorgans.txt
    - The definition of the label codes used in a label map
  - **Chest map**: A label map for a chest image
    - Dimensions: the same as the original whole-lung image
    - Format: a byte image containing image label codes
    - A value of zero indicates that no label has been assigned
  - **Color table**: list of colors associated with labels
    - Format: csv text file, one row for each label
  - **Color map**: true-color image of labeled codes
    - A translation of the **label map** into a color image in which label codes are assigned color values from a **color table**

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## Chest Segmentation and anatomy labeling

Commands:

**vimap**: manages a **label map** image

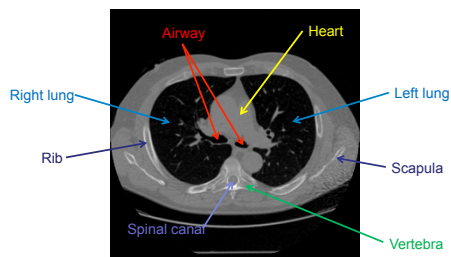
- Allows new segmentations to be added to a **label map**
- Extracts regions defined by a set of labels from a **label map**
- Creates a **color map** from a **label map** using a **color table**

**vcmmod**: Overlays a **color map** onto an **original image** for visualization

**V3view**: Creates 3D visualizations from a **color map**

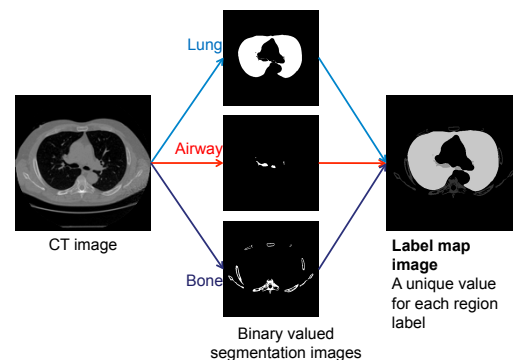
VisionX-V4 *vimap vcmmod vlctovtk*

## Chest CT Image



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## Label (Chest) Map Image



## vimap

- Vimap is a tool for managing a label map file or chestmap
- Functions
  - Add a segmented organ to the map file (-a)
  - Extract an organ of interest from the map file (-e)
  - Delete an organ from the map file (-d)
  - Create a true color organ color map (-t)

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## Organ Label Definitions

- Defines a unique label value for each organ name
  - Label definition management: system users only
- The organ names include:
  - lung, airway, ribs, bone, aorta, heart, ...
- Organ names “dev1” – “dev10” are available for development purpose
- “vchest -l” gives an entire listing of organ names

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## Adding to the Map File

```
vimap -a if=map.vx ig=bone.vx o=bone of=new.vx
```



Existing map image  
"map.vx"  
(with lung)



Bone segmentation  
"bone.vx"  
(binary image)

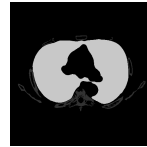


Updated map image  
"new.vx"  
(lung+bones)

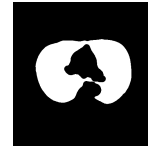
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## Extracting from the Map File

- vimap -e if=map.vx o=lung of=lung.vx



Existing map image  
"map.vx"  
(lung + bones)



Extracted organ  
"lung.vx"  
(binary image)

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## Label Color Table

- Specifies which color to use for each organ label
  - CSV format
  - Each line contains:  
“<Organ>, <Red>, <Green>, <Blue>, <opacity>”
    - RGB values in 0-255 scale
    - Opacity (optional)
      - 0 - 1 scale for VTK 3D rendering (default: 1.0)
      - Existence of this value is used by vcmmod (-c mode)
- Must be converted to VTK color file  
vlctovtk if=<label color table>.vlc of=<VTK color file>.vkc

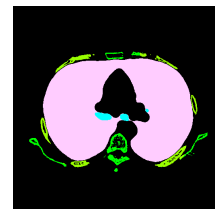
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## Creating a Labeled Color Map

```
vlctovtk if=config1.vlc of=config.vkc  
vimap -t if=map.vx ig=config.vkc of=cmap1.vx
```

config1.vlc:

lung,	255,	204,	255
airway,	0,	255,	255
bone,	0,	255,	0
ribs,	153,	255,	0



cmap1.vx

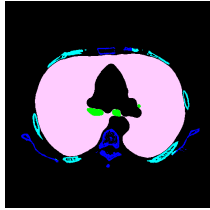
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## Creating a Label (Chest) Color Map

```
vlctovkc if=config2.vlc of=config.vkc
vimap -t if=map.vx ig=config.vkc of=cmap2.vx
```

### Config2.vlc:

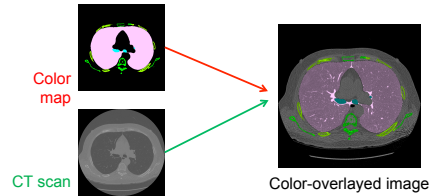
lung,	255,	204,	255
airway,	0,	255,	0
bone,	0,	0,	255
ribs,	0,	255,	255



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## Overlaying a color map onto a CT image

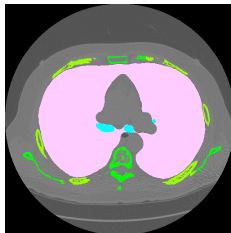
- Four modes available:
  1. Mask over the image: vcmmod -m
  2. Global windowing: vcmmod tl=<low> th=<high>
  3. Organ-dependent windowing: vcmmod -a
  4. Dynamic-dependent windowing: vcmmod -d



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## 1. Label mask over the image

```
vcmmod -m if=cmap.vx ig=scan.vs of=marked1.vx
```



marked1.vx

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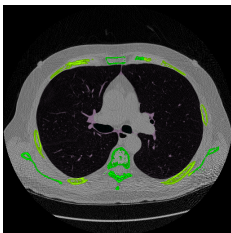
## 2. Global windowing

1. CT image is windowed
  - Using linear windowing between low (tl=) and high (th=) intensities to 0-255
  - The window parameters are tl=<lower-window value> and th=<upper-window-value>
  - Default: tl=<image-min>, th=<image-max>
2. The windowed image is multiplied with the color map for each labeled voxel

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## 2. Global windowing

```
vcmmod if=cmap.vx ig=scan.vs tl=0 th=2000 of=marked2.vx
```



marked2.vx

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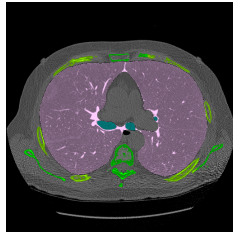
## 3. Organ-dependent windowing

1. CT image is windowed
    - Windowing function is selected for each labeled organ based on the average intensity (Tissue window used for non-labeled region)
- 
- Windowing functions:
    - Lung: Level = -900 HU, width = 750 HU
    - Tissue: Level = 300 HU, width = 1000 HU
    - Bone: Level = 100 HU, width = 1100 HU
2. The windowed image is multiplied with the color map for each labeled voxel

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## Example organ-dependent windowing

vcmod -a if=cmap.vx ig=scan.vs of=marked3.vx



marked3.vx

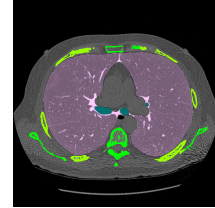
 VisionX-V4 vmap vcmod vlctovtk

## Using opacity field in the color table

vlctovkc if=config3.vlc of=config3.vkc

vcmod -a -c if=cmap.vx ig=scan.vs ih=config3.vkc  
of=marked.vx

config3.vlc:		opacity field	
lung,	255, 204, 255,	0.3	
airway,	0, 255, 255,	1.0	
bone,	0, 255, 0		
ribs,	153, 255, 0		



marked.vx

 VisionX-V4 vmap vcmod vlctovtk

- For each organ,
- If opacity exists: Multiply with windowed CT image
  - If it doesn't exist: Mask over CT image

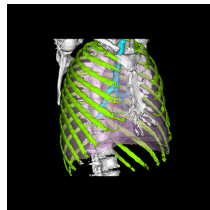
## 3D visualization (1)

vlctovkc if=config4.vlc of=config.vkc

v3view -vtk -c if=map.vx cf=config.vkc -y of=3dvis.vx

### Config4.vlc:

lung,	255, 204, 255, 0.3
airway,	0, 255, 255, 1.0
bone,	250, 250, 250, 1.0
ribs,	153, 255, 0, 1.0



3dvis.vx

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## 3D visualization (2)

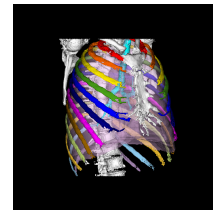
vlctovkc if=config5.vlc of=config.vkc

v3view -vtk -c if=map.vx cf=config.vkc -y of=3dvis.vx

Map file with individual ribs labeled

### config5.vlc:

lung,	255, 204, 255, 0.3
airway,	0, 255, 255, 1.0
bone,	250, 250, 250, 1.0
rrib01,	255, 0, 0, 1.0
...	
rrib12,	165, 134, 179, 1.0
lrib01,	255, 0, 0, 1.0
...	
lrib12,	165, 134, 179, 1.0



3dvis.vx

 VisionX-V4 vmap vcmod vlctovtk