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: *vlmap vcmod and vlctovkc*

Overview

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

- Example: a chest CT image may contains 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:

  – **vlmap**: Manage a label map file
  – **vcmod**: Create visualizations of a chest map

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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:

vlmap: 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**
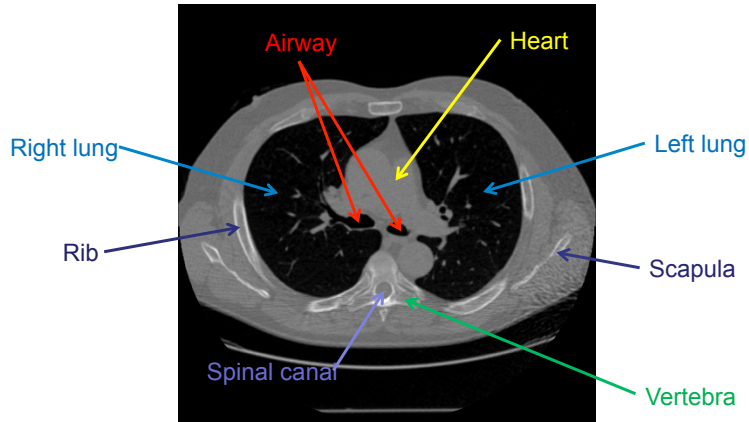- Creates a **color map** from a **label map** using **a color table**

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

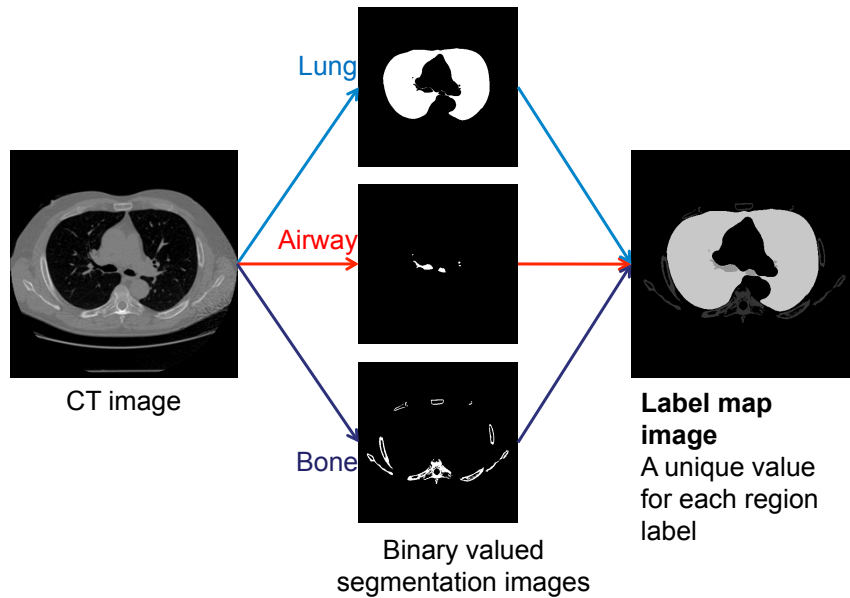**V3view:** Creats 3D visualizations from a **color map**

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Chest CT Image

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Label (Chest) Map Image

CT image

Lung

Airway

Bone

Binary valued
segmentation images

**Label map
image**
A unique value
for each region
label

vlmap

- Vlmap 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

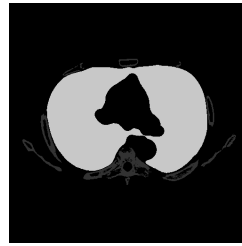*VisionX-V4   vlmap vcmod vlctovtk*

Adding to the Map File

vlmap -a if=map.vx ig=bone.vx o=bone of=new.vx
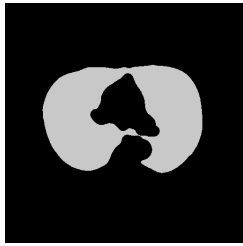
Existing map image
"map.vx"
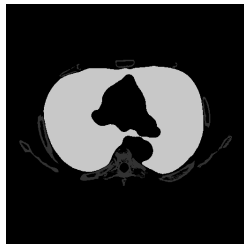(with lung)

Bone segmentation
"bone.vx"
(binary image)

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

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Extracting from the Map File

• vlmap -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 vcmod (-c mode)
- Must be converted to VTK color file

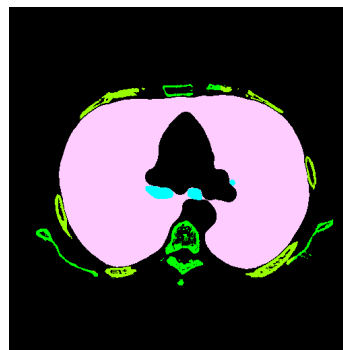 vlctovkc if=<label color table>.vlc of=<VTK color file>.vkc

---

Creating a Labeled Color Map

vlctovkc if=config1.vlc of=config.vkc

vlmap -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
```
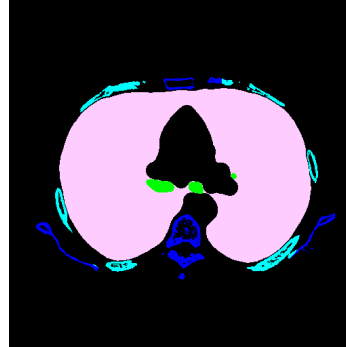

cmap1.vx

Creating a Label (Chest) Color Map

vlctovkc if=config2.vlc of=config.vkc

vlmap -t if=map.vx ig=config.vkc of=cmap2.vx

Config2.vlc:

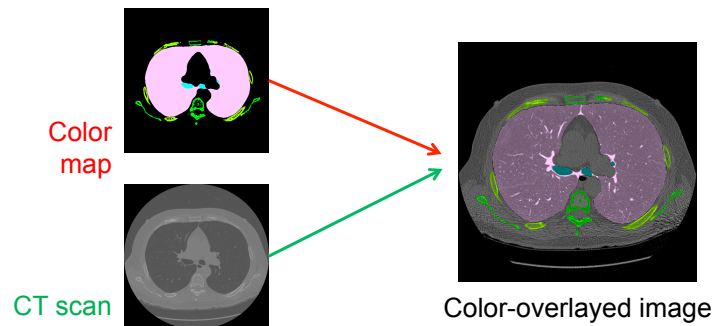|			
lung,	255,	204,	255
airway,	0,	255,	0
bone,	0,	0,	255
ribs,	0,	255,	255

cmap2.vx

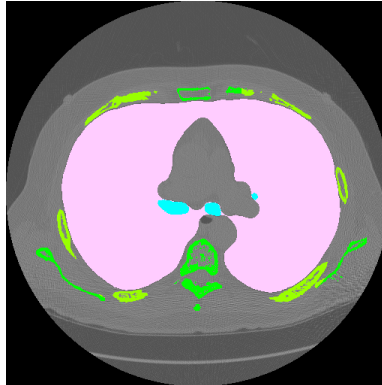# Overlaying a color map onto a CT image

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

Color map

CT scan

Color-overlayed image

1. Label mask over the image

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

marked1.vx

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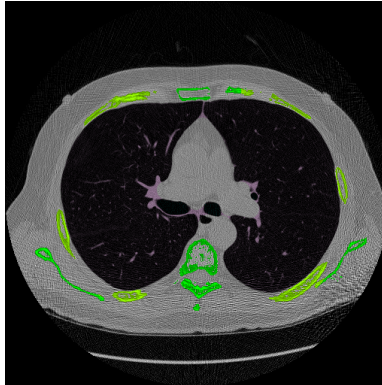
1. CT image is windowed
    – Using linear windowing between low (tl=) and high (th=) intensities to 0-255
    – The window parameters are tl=<lower-window value> and th=<upper-window-value>
    – Default: tl=<image-min>, th=<image-max>
2. The windowed image is multiplied with the color map for each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

2. Global windowing

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

marked2.vx

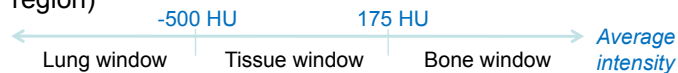
3. Organ-dependent windowing

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)

   -500 HU   175 HU

   Lung window   Tissue window   Bone window   *Average intensity*

   – Windowing functions:
     - Lung: Level = -900 HU, width = 750 HU
     - Tissue: Level = 300 HU, width = 1000 HU
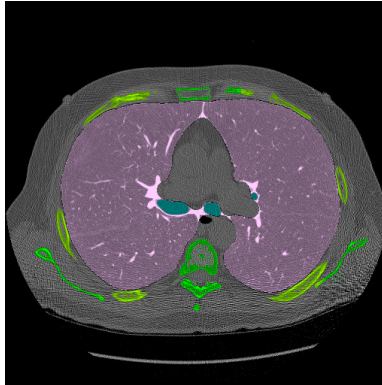   - Bone: Level = 100 HU, width = 1100 HU

2. The windowed image is multiplied with the color map for each labeled voxel

Example organ-dependent windowing

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

marked3.vx

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	
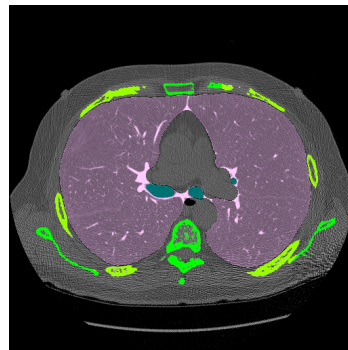
marked.vx

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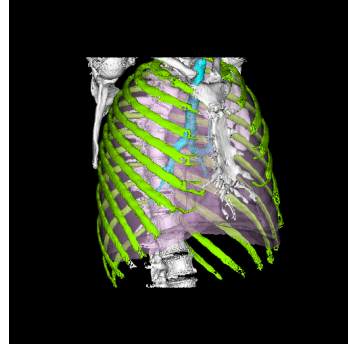- If it doesn't exist: Mask over CT image

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
```


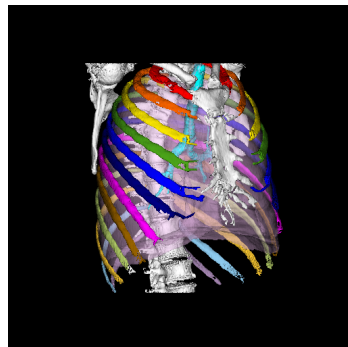3dvis.vx

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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

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