



NA-MIC

National Alliance for Medical Image Computing

<http://www.na-mic.org>

Cardiac Agatston Scoring

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NA-MIC Tutorial Contest: Summer 2014



Learning Objective

This tutorial demonstrates a semi-automated method to segment and identify coronary arteries calcium plaques from EKG-gated non-contrast cardiac CT scans. Then calculate the Agatston score.

Following this tutorial, the user will be able to load scans into Slicer4.3.1, segment calcium plaques, then calculate a calcium score and label statistics.





Pre-requisite

- Pre-requisite tutorial:
 - “Data loading and 3D visualization”
 - Author: Sonia Pujol, Ph.D.
 - <http://www.slicer.org/slicerWiki/index.php/Documentation/4.3/Training>



Material

This tutorial requires the installation of the Slicer4.3.1 release built after 06-05-2014 and the tutorial dataset. They are available at the following locations:

Slicer download page

<http://download.slicer.org/>

Tutorial dataset: [name of dataset]

<http://wiki.na-mic.org/Wiki/index.php/>

[File:CardiacAgatstonMeasures_TutorialContestSummer2014.zip](http://wiki.na-mic.org/Wiki/index.php/File:CardiacAgatstonMeasures_TutorialContestSummer2014.zip)

Note: A SimpleITK bug fix occurred on 06-04-2014 that is necessary for this module to function.

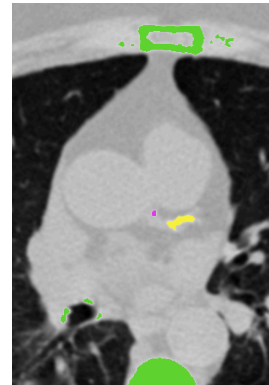
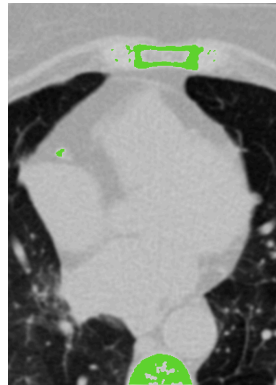
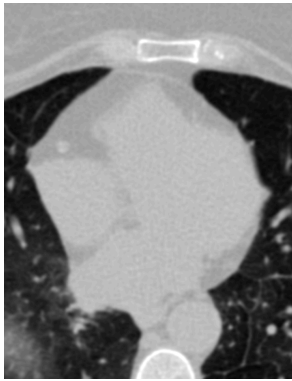






Platforms

Tutorial Name	Platform	Slicer Version	Test Date	Author	Test Results
Cardiac Agatston Measures	Mac OS	4.3.1-2014-06-05	2014-06-19	Jessica Forbes	All tests pass
Cardiac Agatston Measures	Windows 7 64 bit	4.3.1-2014-06-05	2014-06-23	Jessica Forbes	All tests pass
Cardiac Agatston Measures	Linux 64 bit	4.3.1-2014-06-05	2014-06-20	Jessica Forbes	All tests pass



Overview



	Index	Label Name	Agatston Score
	2	Left Main (LM)	4.5229
	3	Left Arterial Descending (LAD)	88.3706
	5	Right Coronary Artery (RCA)	24.2671
	6	Total	117.161



Part 1:
Load
module
and data

Part 2:
Threshold
scan

Part 3:
Identify
calcium
plaques

Part 4:
Calculate
scores
and label
statistics

Part 5:
Save
results



Background

- Cardiovascular Disease is the leading global cause of death: 17.3 million deaths/year
- USA: 600,000 of heart disease per year*
 - Equates to 1 in every 4 deaths
- 40-60% have no cardiac symptoms before the event**
- Important to identify asymptomatic patients at risk of coronary events

*<http://www.cdc.gov/heartdisease/facts.htm>, February 19, 2014

**Myerburg et al. *Am J Cardiol* 1997 Virmani et al. *Cardiovasc Pathol*. 2001



Background

120 KEV Ranges

HU Range	X-Factor
130-199	1
200-299	2
300-399	3
≥ 400	4

Each pixel of an EKG-gated non-contrast cardiac CT scan has an attenuation/density unit called Hounsfield Unit (HU).

- Water = 0 HU
- Air = -1000 HU

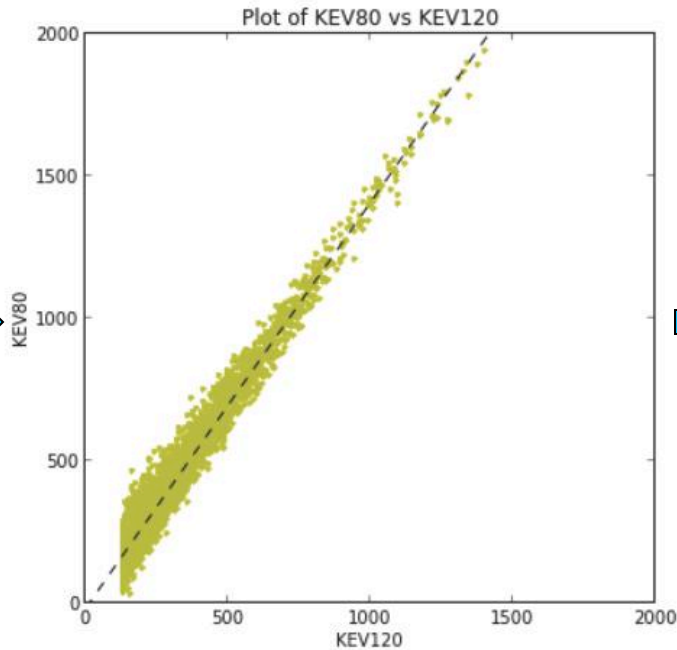
The Agatston score is a multiplication of calcium area by a weighting factor (X-Factor) related to peak HU pixel.



Background

120 KEV Ranges

HU Range	X-Factor
130-199	1
200-299	2
300-399	3
≥ 400	4



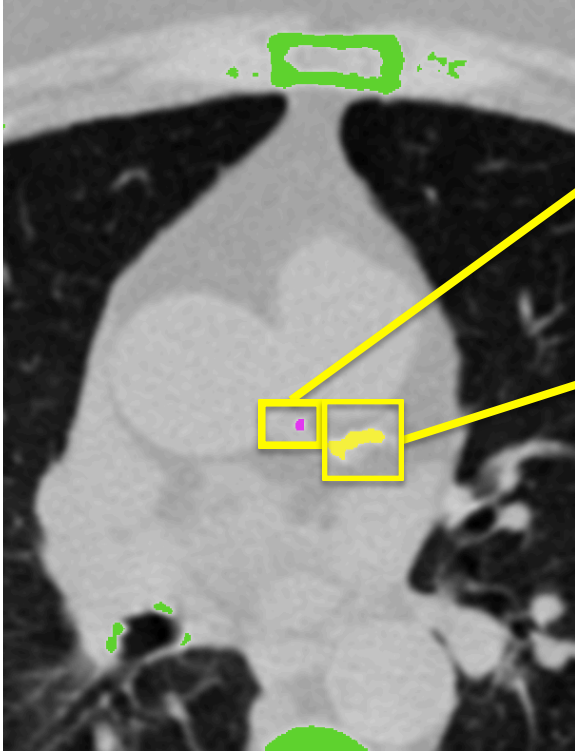
80 KEV New Ranges

HU Range	X-Factor
167-265	1
266-407	2
408-550	3
≥ 551	4

X-Factor ranges determined for 120 KEV only, so we calculated new ranges for lower radiation 80 KEV scans based on HU intensity values.



Background



Island 1 Agatston Score = Area1 x X-Factor1
EX: $16 = 8 \times 2$

Island 2 Agatston Score = Area2 x X-Factor1
EX: $80 = 20 \times 4$

Total Agatston Score = Sum of All Island
Agatston Scores on every slice
EX: $96 = 16 + 80$



Part 1: Loading Extension

The screenshot shows the 3D Slicer application interface. The 'View' menu is open, and the 'Extension Manager' option is highlighted with a yellow box. A blue callout box with a yellow arrow points to the 'Extension Manager' option, containing the text 'Open the Extension Manager listed under View'. The main window displays a 'Welcome' message and several buttons for loading data and customizing the interface.

3D Slicer 4.3.1-2014-06-24

Python Interactor ⌘3
Extension Manager ⌘4
Module Panel ⌘5
Toolbars
Layout
Error Log ⌘0

3DSlicer

Welcome

Load DICOM Data Load Data
Customize Slicer Download Sample Data

Feedback
About
The Main Window
Loading and Saving

Open the Extension Manager listed under View



Part 1: Loading Extension

Extensions Manager

Manage Extensions (0) Install Extensions

Search...

Slicer Extensions

Kitware

Categories

- All
- Cardiac (1)**
- Cardiac MRI toolki (1)
- Developer Tools (3)
- Diffusion (4)
- Editor Effects (1)
- Examples (4)
- Exporter (1)
- Filtering (1)
 - Morphology (1)
- IGT (6)
- Informatics (4)
- Mesh Generation (1)
- Microscopy (1)
- Multidimensional data (1)
- Quantification (2)
- Radiotherapy (2)
- Registration (2)
- Remote (1)
- Scoliosis (1)
- Segmentation (11)

CardiacAgastonMeas...
Jessica Forbes (Ulowa)...
(0)

INSTALL

Select the Cardiac Category

Then select Install

A restart is required to install an Extension

Restart Close



Part 1: Loading Extension

3D Slicer 4.3.1-2014-06-05

Modules:

- All Modules
- Annotations
- Data
- DataStore
- DICOM
- Markups
- Models
- Scene Views
- Subject Hierarchy
- Transforms
- View Controllers
- Volume Rendering
- Volumes
- Welcome to Slicer
- Wizards
- Informatics
- Registration
- Segmentation
- Quantification
- Diffusion
- IGT
- Filtering
- Surface Models
- Converters
- Endoscopy
- Utilities
- Developer Tools
- Legacy
- Testing
- Examples
- MultiVolume Support

Cardiac Agatston Measures

Change the Module to Cardiac Agatston Measures.



Part 1: Loading Data

Open files using "DATA" or "DCM"

Choose File to Add

Select OK

3D Slicer 4.3.1-2014-06-05

Modules: Cardiac Agatston Measures

3DSlicer

Help & Acknowledgement

Advanced - Reload & Test

Reload

Reload and Test

Input Parameters

Input Volume: Select a Volume

80 KEV

120 KEV

Threshold Volume

Choose Directory to Add

Choose File(s) to Add

File	Description
/scratch/cardiac_agatston_score_test_scan.nii.gz	Volume

Reset

OK

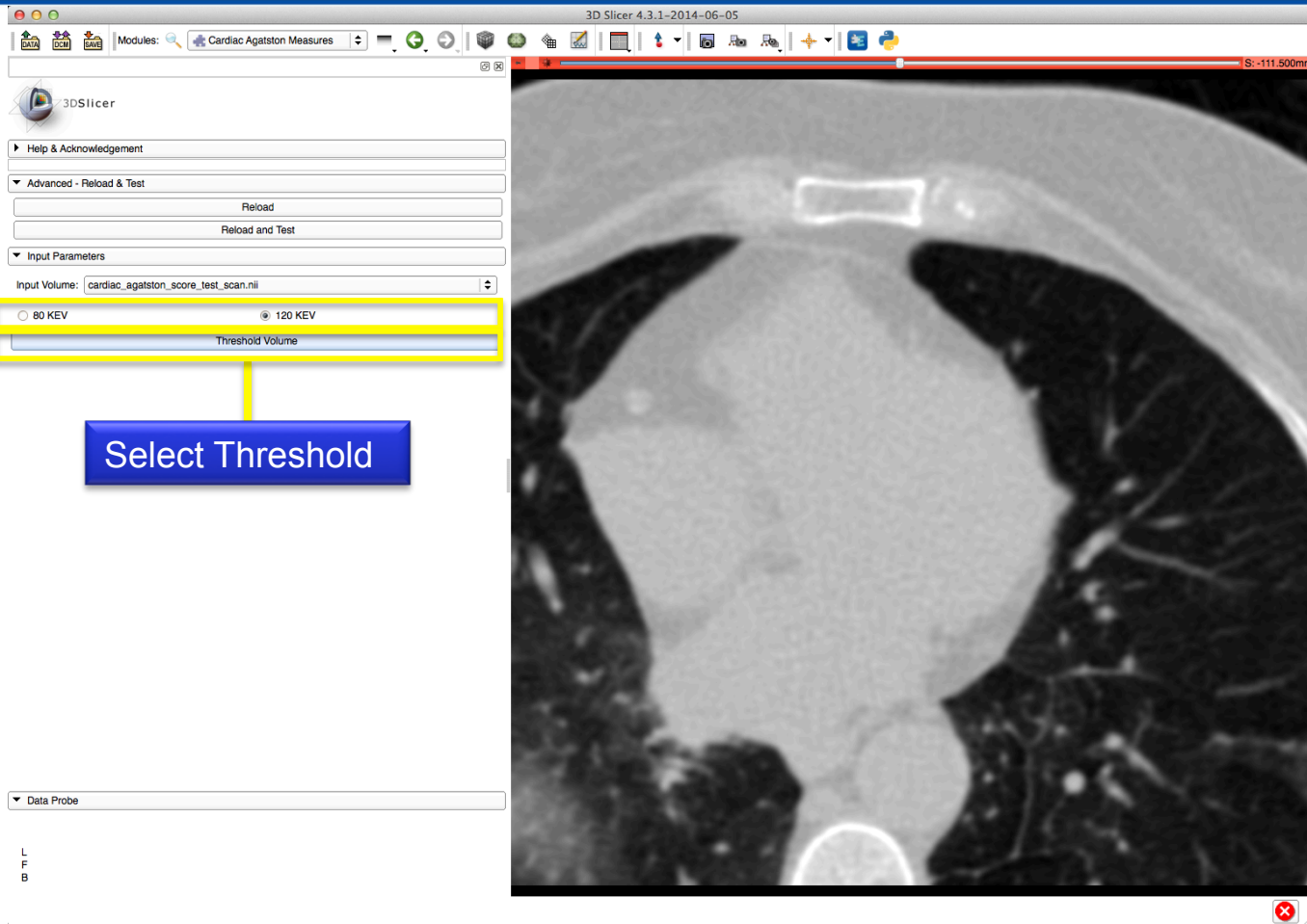
Cancel

Data Probe

L
F
B



Part 2: Thresholding Scan



Choose if scan is 80 KEV or 120 KEV

Select Threshold



Part 3: Identifying plaques

3D Slicer 4.3.1-2014-06-05

Cardiac Agatston Measures

3DSlicer

Help & Acknowledgement

Advanced - Reload & Test

Reload

Reload and Test

Input Parameters

Input Volume: cardiac_agatston_score_test_scan.nii

80 KEV

120 KEV

Threshold Volume

Edit Selected Label Map

Default

LM

LAD

LCX

RCA

Undo/Redo/Default:

Active Tool:

Label: default 1

Apply

Chart Agatston Score Ignore Zero

Save

Data Probe

S: -108.500mm

Click on one of the 5 label selection buttons

Click on an island of calcium plaque to identify as one of the 5 labels



Part 3: Identifying plaques

3D Slicer 4.3.1-2014-06-05

Cardiac Agatston Measures

3DSlicer

Help & Acknowledgement

Advanced - Reload & Test

Reload

Reload and Test

Input Parameters

Input Volume: cardiac_agatston_score_test_scan.nii

80 KEV

120 KEV

Threshold Volume

Edit Selected Label Map

Default

LM

LAD

LCX

RCA

Undo/Redo/Default: [undo] [redo] [default]

Active Tool: ChangelsandEffect

Label: Right Coronary Artery (RCA) 5

Click on segmented region to change all segmentation directly connected to it to current label.

Apply

Chart Agatston Score [checkbox] Ignore Zero

Save

Data Probe

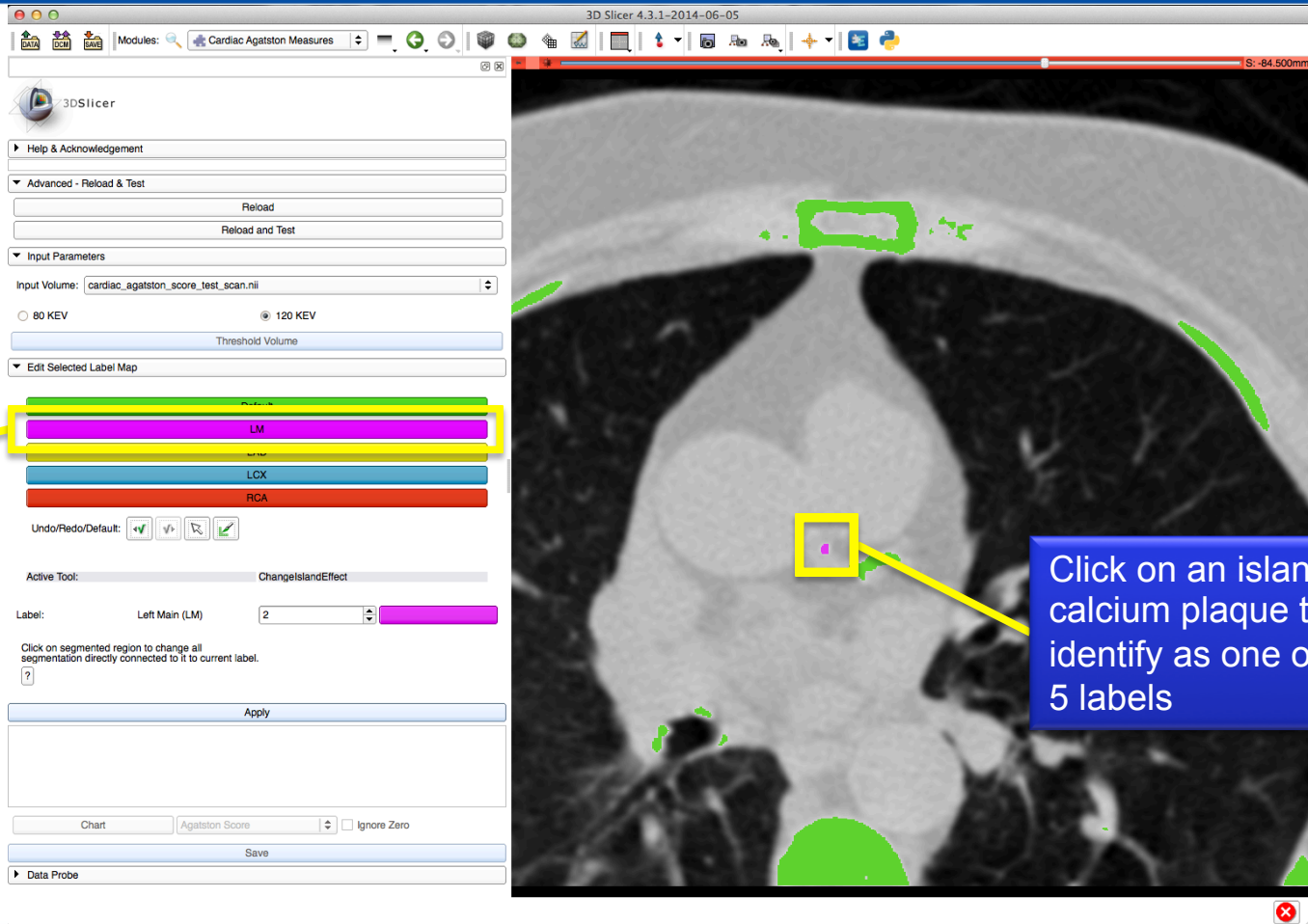
S: -108.500mm

Click on one of the 5 label selection buttons

Click on an island of calcium plaque to identify as one of the 5 labels



Part 3: Identifying plaques

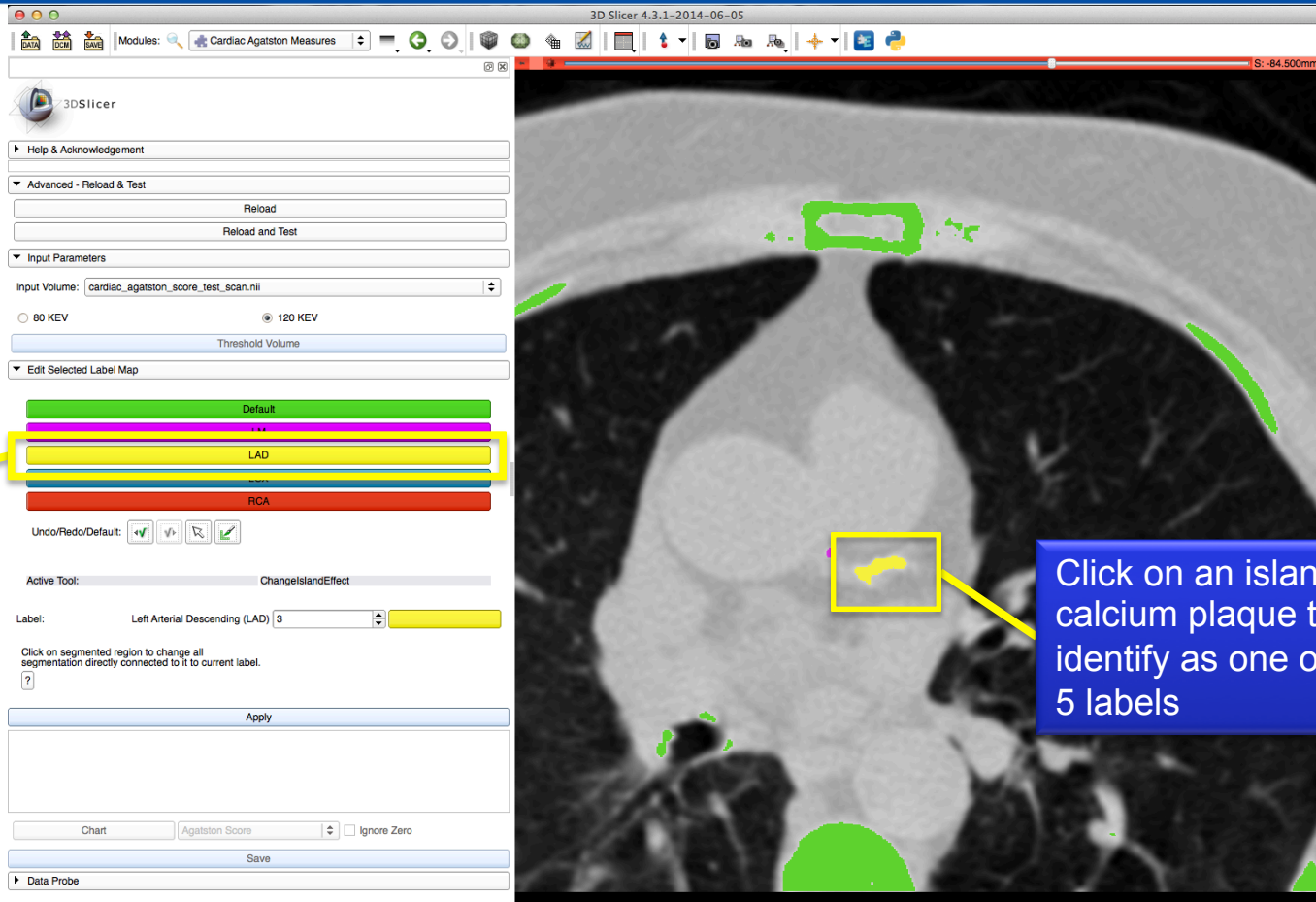


Click on one of the 5 label selection buttons

Click on an island of calcium plaque to identify as one of the 5 labels



Part 3: Identifying plaques



Click on one of the 5 label selection buttons

Click on an island of calcium plaque to identify as one of the 5 labels



Part 4: Calculating Scores

Select Apply to calculate the Agatston score for individual labels and total

Apply										
	Index	Label Name	Agatston Score	Count	Volume mm ³	Volume cc	Min	Max	Mean	StdDev
	2	Left Main (LM)	4.5229	26	6.78436	0.00678436	137	276	201.538	44.7251
	3	Left Arterial Descending (LAD)	88.3706	254	66.2779	0.0662779	131	654	290.76	121.42
	5	Right Coronary Artery (RCA)	24.2671	104	27.1374	0.0271374	130	384	208.077	61.6902
	6	Total	117.161	384	100.2	0.1002	130	654	262.326	111.709

Chart	Agatston Score	<input type="checkbox"/> Ignore Zero
	Count	
	Volume mm ³	
	Volume cc	
	Min	
	Max	
	Mean	
	StdDev	

Select Chart and Column to compare the values for each label



Part 4: Calculating Scores

3D Slicer 4.3.1-2014-06-05

Modules: Cardiac Agatston Measures

3DSlicer

Help & Acknowledgement

Advanced - Reload & Test

Reload

Reload and Test

Input Parameters

Input Volume: cardiac_agatston_score_test_scan.nii

80 KEV 120 KEV

Threshold Volume

Edit Selected Label Map

Default

LM

LAD

LCX

RCA

Undo/Redo/Default:

Active Tool: DefaultTool

Label: Left Arterial Descending (LAD) 3

Apply

Index	Label Name	Agatston Score
2	Left Main (LM)	4.5229
3	Left Arterial Descending (LAD)	88.3706
5	Right Coronary Artery (RCA)	24.2671

Chart: Agatston Score Ignore Zero

Save

Data Probe

Label Statistics

Agatston Score

Left Main (LM) Left Arterial Descending (LAD) Right Coronary Artery (RCA) Total

Label

S: -84.500mm R: -7.399mm A: 146.836mm



Part 5: Saving Results

Select Save.
This saves the MRML scene and a CSV file containing the calculated scores and statistics.

Then select the New Folder icon.
Rename the folder.

Choose the newly created folder.

Index	Label Name	Agatston Score	Count
2	Left Main (LM)	4.5229	26
3	Left Arterial Descending (LAD)	88.3706	254
5	Right Coronary Artery (RCA)	24.2671	

Label Statistics

Agatston Score

Left Main (LM) Left Arterial Descending (LAD) Right Coronary Artery (RCA) Total

Label

Save

Find Directory

Look in: /scratch/CardiacAgatstonModuleTutorial

Name

test

Size

Directory: New Folder

Files of type: Directories

Choose

Cancel



Conclusion

- All tests passed with:
 - Linux 64-bit
 - MacOS
 - Windows 7 64-bit



Acknowledgments



National Alliance for Medical Image Computing

NIH U54EB005149

SINAPSE Lab

SimpleITK