

# CT TRUEVIEW – CARDIAC CT IN THE CATHLAB

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## Abstract

The aim of the CT TrueView project is the integration of cardiac CT images and its derived information in the cathlab [1]. The intended clinical application is to guide the treatment of stenosis in the coronary arteries.

## 1 Introduction

The development of Multi-Slice Computed Tomography (MSCT), together with ECG gating, has brought a reliable 3D reconstruction of the heart and the coronary arteries within reach (see figure 1). Iodine contrast agent is injected intravenously during the CT scan acquisition, to make the heart structures visible. The cardiac CT reconstruction allows an evaluation of coronary artery disease, with respect to stenotic area and plaque. The CT reconstruction of the coronary arteries may indicate that interventional treatment (i.e. applying stents) is needed.

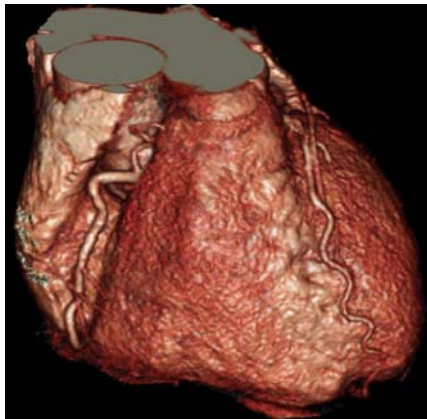


Figure 1: Cardiac CT

Stents are placed by a percutaneous coronary intervention in which the stent, mounted on a balloon catheter, is inserted through a small incision in the groin and inflated at the site of the lesion. The intravascular devices are guided using an X-ray C-arm system in a cathlab (see figure 5). The injection of iodine contrast medium through the catheter enables the visualization of the vasculature (see figure 2).



Figure 2: A coronary angiogram, acquired with an X-Ray C-arm system.

In this article we discuss how the cardiac CT data can be used in the pre-treatment planning, and how in it can be integrated peri-interventionally.

## 2 Workflow

The latest generation CT scanners with faster gantry rotations, multi-slice 64-row acquisitions and ECG gating have substantially improved both temporal and spatial resolutions to adequately visualize the moving coronary vasculature. Presently, a spatial resolution of 0.4 mm with a temporal resolution as low as 83 msec during cardiac acquisition of less than 15 seconds can be achieved [2].

The reconstructed images are transferred to a dedicated CT workstation (Extended Brilliance Workspace, Philips Medical Systems) and loaded into a dedicated cardiac application (Comprehensive Cardiac Analysis). After the automated heart segmentation and the semi-automatic extraction of the coronary arteries, the areas of interest can be interactively analyzed using curved Multi-Planar Reformats (MPR) and 3D rendering tools. Once the decision is made to treat the patient in the cathlab, the CT data, the heart segmentation and the extracted coronary arteries are transferred to the cathlab 3D workstation (XtraVision, Philips Medical Systems), either over the network, or using CD or

DVD. The data is transferred using the DICOM protocol.

### 3 Methods

After the cardiac CT datasets have been imported to the XtraVision workstation, several methods are being used to assist the physician during the interventional procedure.

#### 3.1 TrueView map

Spatial foreshortening is the distortion of geometrical structures (e.g. vessels) when depicted at an angle. Foreshortening of the vessel geometry in X-ray images makes it difficult to assess their true length, and therefore it is preferable to select X-ray projection views that have minimal foreshortening for the vessel segments of interest.

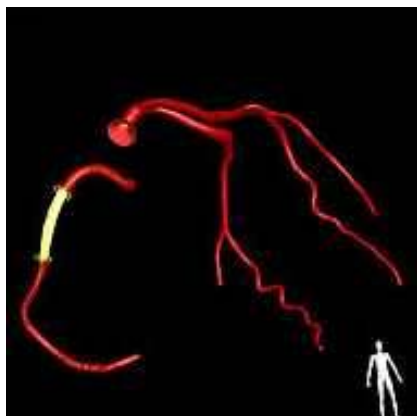


Figure 3: A selected segment of a coronary artery.

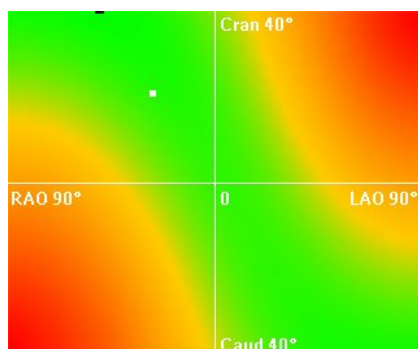


Figure 4: The TrueView map. The vertical axis represents the angulation of the C-arm system, and the horizontal axis the rotation. The color of a point on the TrueView map represents the amount of foreshortening of the selected coronary segment.

The TrueView map [2,3] can be used to plan a C-arm position that provides a view with minimal foreshortening of the selected coronary artery segment, see figures 3 and 4.

#### 3.2 Follow C-arc

The orientation of the coordinate systems of the CT dataset and the X-ray C-arm are registered, based on the DICOM information.

When the Follow C-arc mode is active, the viewing incidence of the CT dataset is matched in real time with the current rotation and angulation of the C-arm geometry (see figure 5). This allows the clinician to use the view on the CT dataset to predict an optimal working position for the C-arm without actually using X-ray.

The counterpart of this function is called 3D APC (Automatic Positioning Control), which allows the C-arm to be moved to a viewing incidence corresponding to the 3D rendering of the CT dataset. Desired working positions can be planned (e.g. using the TrueView map) and stored before starting the procedure and later recalled during the procedure when needed.

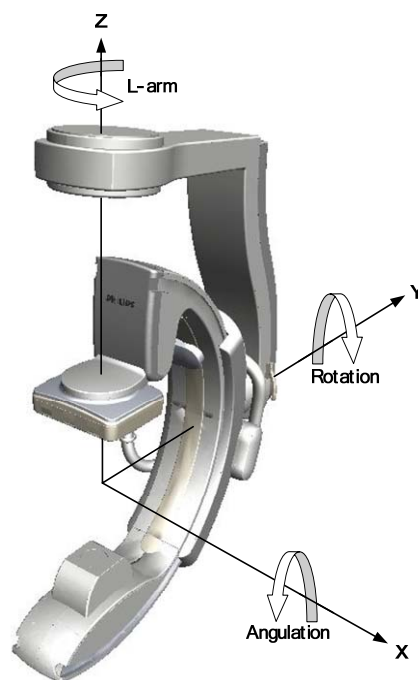


Figure 5: The C-arm geometry can rotate around three axis of freedom. The rotation and angulation angles can be automatically steered to match the viewing incidence on the CT data, using the 3D APC function.

### 3.3 Curved MPR

A curved MPR [4] representation of the vessels is available (see figure 6), and helps the physician to find the best view on the stenosis and the surrounding calcified plaque. Since the curved MPR is coupled to the 3D view of the CT dataset, it will pursue the 3D representation in the follow C-arc mode.

The curved MPR is complemented with a cross-sectional view and a measurement tool, providing true length along the 3D centerline as well as cross sectional measurements.

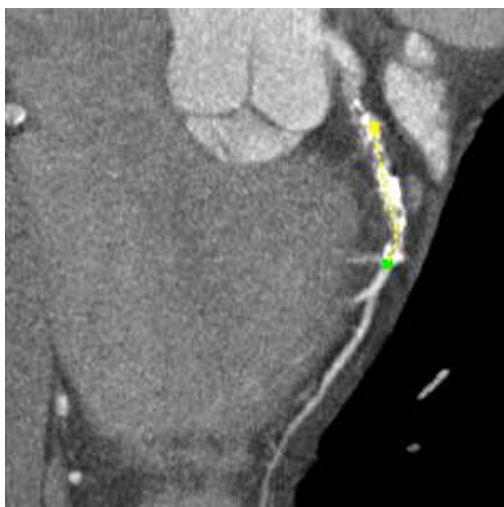


Figure 6: A curved MPR of a coronary artery. The curved MPR visualization “unwinds” the vessel in the direction perpendicular to the view (the z-axis of the view), and therefore does not contain any foreshortening.

### 3.4 Virtual X-ray

An X-ray angiography like representation [5] of the coronary arteries, based on the CT dataset, is provided (see figure 7), in order to assist the physician while planning the optimal views. This type of visualization allows a better impression of the X-ray angiographic view that will be generated in a particular viewing incidence.

### 3.5 Overlay

An overlay visualization of the CT dataset on the X-ray image can be presented for guidance during the procedure. This overlay application is preceded by a manual registration step.

Further work in progress concerns the (semi-) automatic registration of the segmented CT coronary vessel tree and/or a selected vessel segment with an X-ray image stream. We put emphasis on performing



Figure 7: An X-ray-like visualization of the CT data.

this within limited time, since such operations are executed during the intervention.

## 4 Conclusion

The TrueView map, curved MPRs, follow C-arc and overlay functionality have been integrated in a prototype application, which has been installed in the Lenox Hill Hospital, New York, USA, and the University of Colorado Hospital, Denver, USA.

The prototype has been used during live cases at the EuroPCR conference of 2006 and 2007, and the Transcatheter Cardiovascular Therapeutics (TCT) conference in 2006. It has been used during the minimal invasive treatment of coronary artery disease of over 20 patients.

The first qualitative clinical feedback indicated that the integration of cardiac CT data helps in improving planning and guidance of cardiovascular interventional therapies. The optimal system angles from true 3D datasets enable better stent length selection and in addition can lead to a reduction in the use of contrast medium and radiation dose.

An extensive clinical study, intended to provide quantitative data, is currently being planned.

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