

Cardiovascular and Pulmonary Model Format (CPM) Version 1.0

(Draft Version 04-01-2009)

A file format for cardiovascular and pulmonary models (CPM) has been developed. While several existing file formats (e.g. MRML) were investigated, a new file format has been proposed uniquely enabling the representation of anatomy and physiology necessary for cardiovascular and pulmonary simulation. Based on direct past experience of the principal investigator on previous grants, the driving principles behind the design of the format were simplicity and functionality. That is, a common pitfall of new proposed standards is that they are too complex and comprehensive so that no full implementation exists (or takes years to develop).

The format has several required conventions. First a parent level directory must be created, and all the files and directories must adhere to the conventions specified in the "Cardiovascular and Pulmonary Model Format Version 1.0" document to be posted on the website described in the following section (D2). It should be noted that the standard describes valid methodology for user and proprietary extensions to the data contained in the directory. For example, a vendor may implement a custom anatomic model representation. As long as the required representation is also created, both the proprietary and the standard anatomic representations can be created and stored in a single CPM directory structure. By convention, each "patient" or "subject" will have a given directory (e.g. "coronary_subject" and "carotid_subject").

Under the parent directory, a single CPM file (by convention subject.cpm) will contain the information to specify the contents of the "subject directory." This CPM file utilizes the now-common Extensible Markup Language (XML) to store information. XML is a simple, very flexible text format derived from SGML (ISO 8879). While originally developed for electronic publishing, XML today is used in numerous applications for the exchange of a wide variety of data on the Web and elsewhere. See <http://www.w3.org/XML/> for additional details on the XML standard.

Much of the content associated with a model (e.g. image data, finite element meshes, etc.) can be large and has data type-specific information. For large data structures, CPM relies on using data structures widely supported and standardized by the Visualization Toolkit (VTK). VTK has file formats for representing medical image data (vtkStructuredGrid), finite element analysis results (vtkUnstructuredGrid), and surfaces (vtkPolyData). It should be noted that these files are also stored by convention in XML format in the CPM directory structure. Additional information on the Visualization Toolkit and its supported file formats can be found at www.vtk.org.

A document containing the complete CPM format specification will be posted on the Cardiovascular and Pulmonary Model Repository website as shown in Figure 5. A sample of tags is given in Table 1.

Tag	Required Tags [R] Optional Tags [O] Text
<cardiovascular_pulmonary_model> <ul style="list-style-type: none"> • <patient_information> • <anatomic_model> <ul style="list-style-type: none"> • <coarse_surface_representation> • <dense_surface_representation> • <ordered_vessel_2d_segmentations> • <ordered_vessels> • <physiologic_information> <ul style="list-style-type: none"> • <measured_brachial_artery_blood_pressure> • <measured_volumetric_flow_rate_waveform> • <measured_heart_rate> • <image_temporal_data_series> ○ <image_data_series> • <vtkpolydata_object> • <vtkstructuredgrid_object> • <vtkunstructuredgrid_object> 	creation_date="int" [R] modification_date="int" [R] creation_date="int" [R] modification_date="int" [R] patient_name="string" [O] patient_ID="string" [O] patient_Age="int" [R] creation_date="int" [R] modification_date="int" [R] identifier="int" [R] image_data_identifier="int" [R] vtkPolyData_identifier="int" [R] vtkPolyData_identifier="int" [R] identifier="int" [R] text="list of identifiers" [R] identifier="int" [R] text="list of identifiers" [R] creation_date="int" [R] modification_date="int" [R] peak_systolic_pressure= [R] peak_diastolic_pressure= [R] creation_date="int" [R] modification_date="int" [R] identifier="int" [R] text="list of {t Q}" [R] rate="int" (bpm) [R] number_of_frames="int" [R] frame="int" [R] time="double" [R] identifier="int" [R] file= [R] identifier="int" [R] file= [R] identifier="int" [R] file= [R]

Table 1: Sample of Cardiovascular and Pulmonary Model Tags.