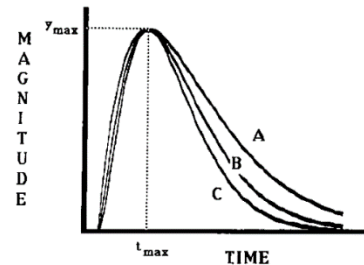


Documentation of Brain Perfusion Digital Simulator

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- Main Script for Digital Perfusion Phantom Forward Projector
 - User sets parameter on whether to create new regions of interest (ROI) or to load in a .mat file containing regions of interest
 - User sets parameter on whether to create new time attenuation curve (TAC) for each ROI or to load in a .mat file containing the TACs
 - User sets parameter on whether to use the brute force method or the faster scaling method to do forward projection
 - Creating New ROIs
 - User sets frame rate and acquisition time
 - User sets parameter on whether or not to use smoothing on the ROIs
 - User sets parameter on whether to identify for set of voxels as ROI (manually) or to create spherical ROIs ([0,1] mask)
 - Creating Spherical ROI
 - Set radius and center of each sphere and create corresponding spherical ROIs
 - Creating New TACs
 - User specifies max attenuation, time delay, time at which max attenuation occurs, and alpha parameter
 - Call the time attenuation curve generator function (shown below)
 - Call the specified projection method function (shown below)
- Time Attenuation Curve Generator Function
 - For each set of TAC curve parameters create a corresponding vector of discrete time points (for each frame) corresponding to a gamma variate function over the total acquisition time
 - $y(t') = y_{max} t'^{\alpha} \exp(\alpha(1 - t'))$
 - $t' = \frac{t-t_0}{t_{max}-t_0}$
 - t_0 is the delay time
 - $y_{max} = y(t_{max})$
 - α determines onset, decay
- Brute Force Projection Function – Addition in Voxels
 - Load head phantom voxel based image
 - Set CT scanner parameters including voxel size, angle step for each frame, detector size, source-axis distance, source-detector distance
 - For each frame, scale the ROI voxel based image by the enhancement value from the TAC's corresponding time point, add to head phantom image, and complete a separable footprint forward projection
- Faster Scaling Projection Function – Addition in Projections
 - Load head phantom projection data for given frame rate



- Create static projections of region of interest using static forward projector function (shown below)
- For each frame, scale the ROI projection by the enhancement value from the TAC's corresponding time point and add to the corresponding head phantom projection\
- Static Forward Projector Function
 - Set CT scanner parameters including voxel size, angle step for each frame, detector size, source-axis distance, source-detector distance
 - Complete a separable footprint forward projection for each frame

Motivation for faster scaling projection function compared to brute force method:

The brute force method simulates data collection that resembles actual clinical data collection. This includes changes in voxel attenuation values as the contrast bolus moves throughout the brain vasculature. However, our software moves volumes to GPU processors to complete a separable footprint forward projection due to its high computational cost. Our brute force method projects a new volume for each frame as the attenuation values for different voxels change.

Because a forward projection is simply a set of line integrals through the volume, we can think about projecting a region of interest and scaling the projection by a corresponding enhancement value. This projection can then be added to the head phantom projection. This faster method only needs to create a static projection of only the ROI (one volume) assuming the projection data of the head phantom is stored previously.