The use of L-System for Modeling Purkinje Fibers

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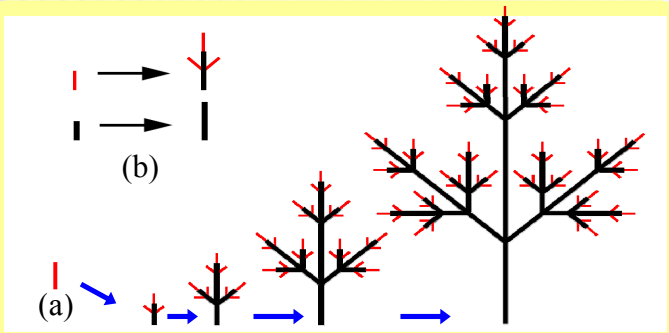
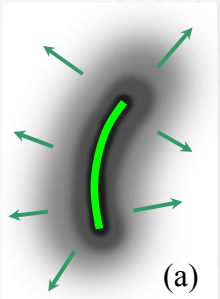
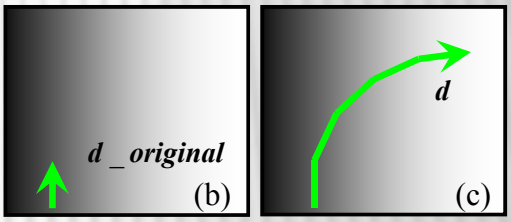
Purkinje fibers are located in the ventricular walls of the heart, just beneath the endocardium and conduct electrical stimulus from the right and left bundles to ventricular myocardium. Recently, anatomists (Shimada et al.) revealed that Purkinje fibers construct a mesh structure. In this poster, we present a method for modeling the mesh structure of Purkinje fibers by applying *L-System*. L-System is a formal grammar which defines a growth of a fractal structure by *generating rules* and an *initial structure*. We modify the growth process of L-System so as to construct uniformly distributed mesh structures. We design a generating rule based on an observation of anatomical photograph, and manually specify three terminal positions of the right bundle branch, the left anterior fascicle, and the left posterior fascicle on a 3D heart model. We then grow fibers starting from each of the three positions based on the specified generating rule. Using the modified L-System, we achieved to create 3D Purkinje fiber models which have a similar structural characteristic to the real photograph.



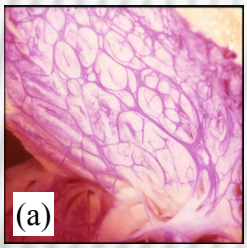
L-System defines fractal structures by an initial structure (a) and generating rules (b) [PL90].

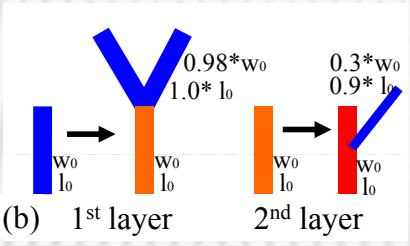


$$d = \frac{d\_original + w1 * d\_gradient}{\| d\_original + w1 * d\_gradient \|}$$

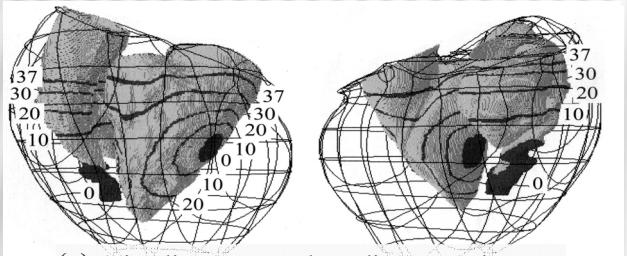


Modified L-System: we construct *distance field* for each branch (a). A growing branch (b) gradually curves along the gradient of the distance field (c).

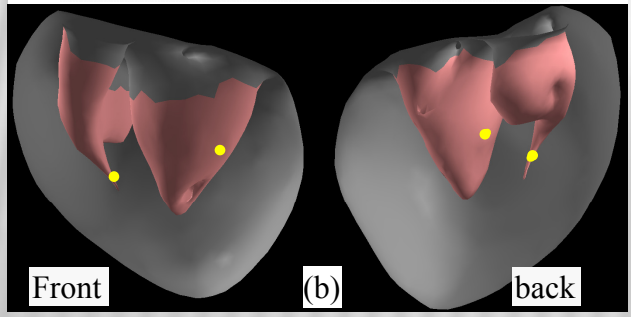




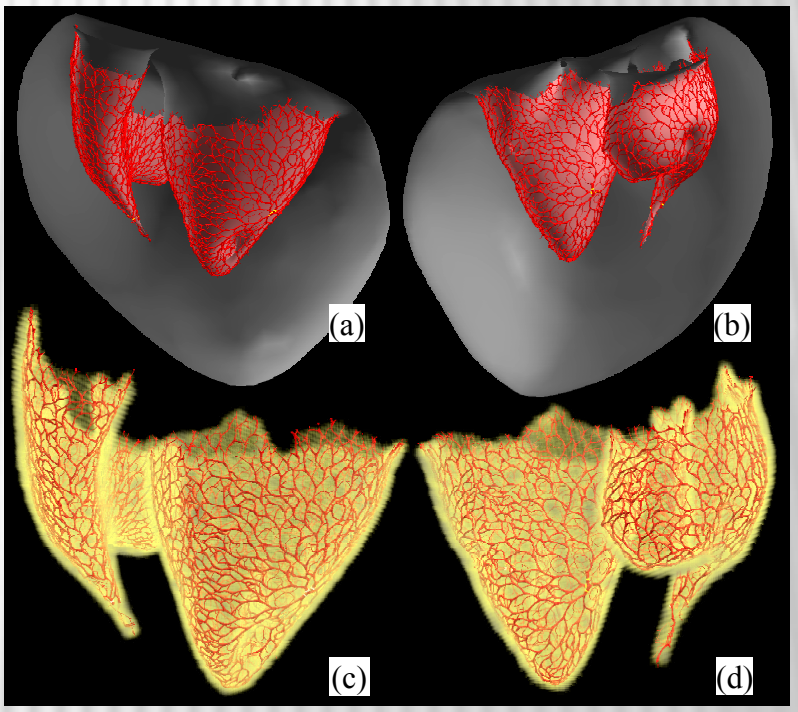
Purkinje fibers of a sheep (a) supplied by Tatsuo Shimada* and generating rules (b). We design these rules and parameters based on this image.



(a) Stimuli area on endocardium. Numbers are times (ms) when stimuli occur at points[Oka03].



Start points: Our system supports the user to manually specify starting points of growth. We specified them (b) based on [Oka03] (a).



Purkinje fibers created by our method. Looked from front (a) (c) and back (c) (d).

Future work contains
i) Extract growth rules from photographs automatically
ii) Apply the resulting models to simulations

[PL90] Prusinkewicz. P, et al.: "*The algorithmic beauty of plants*", 1990.
[Oka03] Okamoto. Y,: "*Physiome of heart*", 2003.
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