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SMIT

Simulation of Deformable Vasculature for Robot-assisted Endovascular Catheterization

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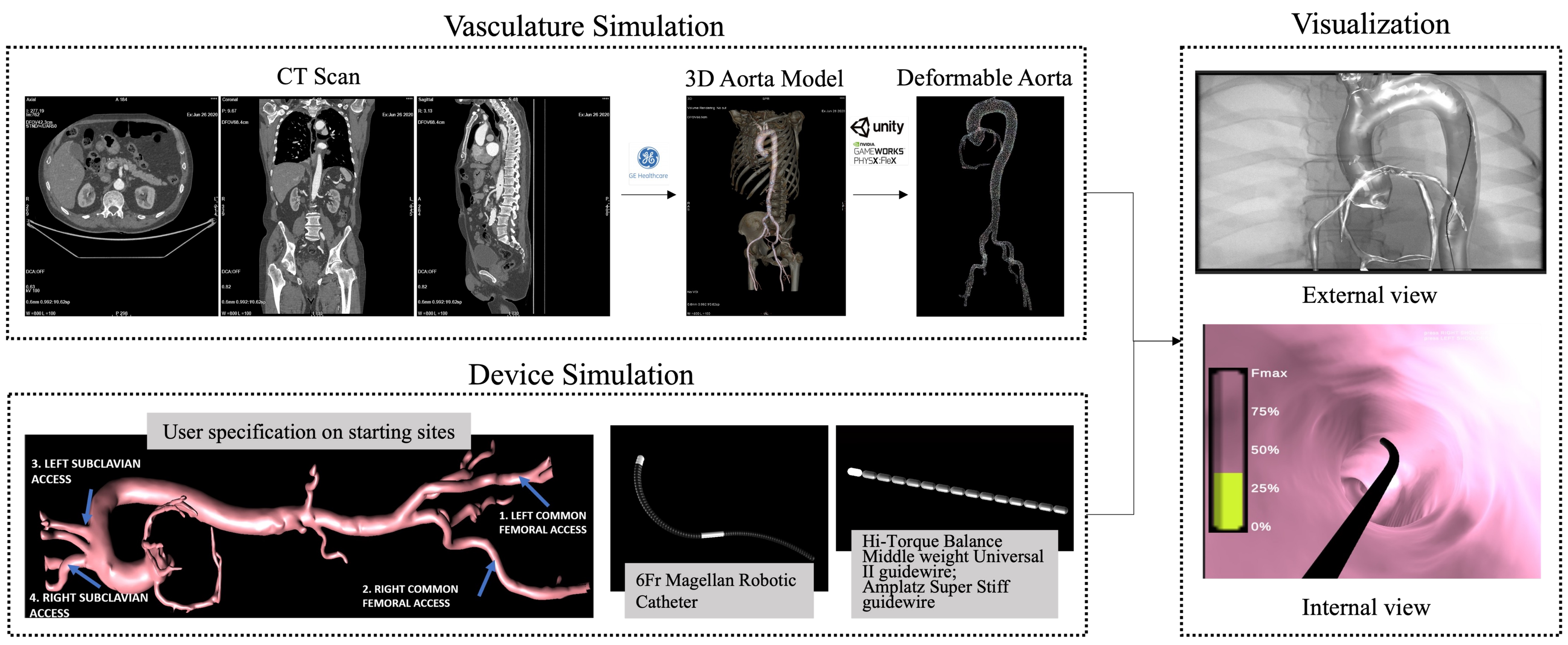
Introduction

A virtual endovascular catheterization system that simulates the characteristics of robotic catheters and deformable vessels can provide a dynamic environment for robot-assisted interventions simulation.

Although state-of-the-art research investigates deformations of vessels due to the device's contact, vessels movement due to heartbeat motion, and the robotic catheter's steerability, a modeling and simulation method involving all those components in one individual framework has not been reported yet.

Materials and Methods



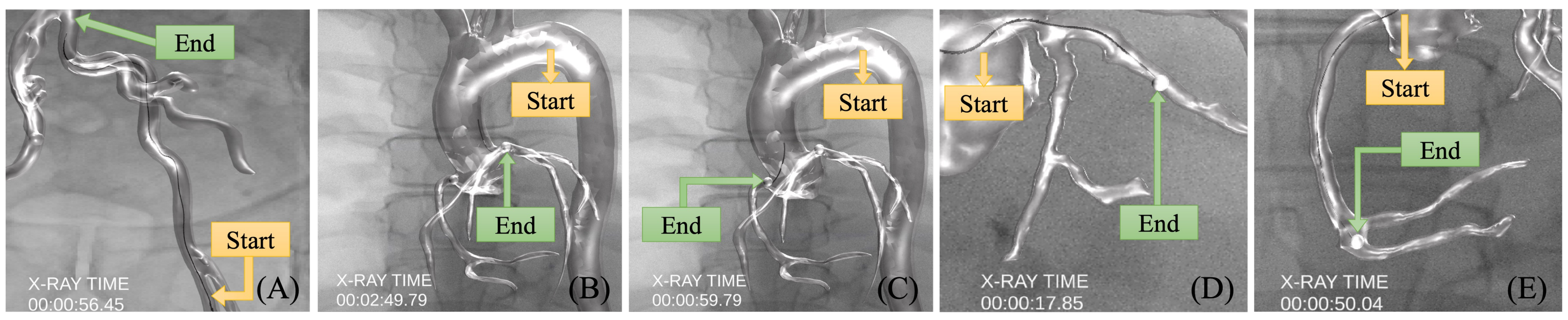
The overview of the proposed system presents

- the workflow from the extraction of the patient-specific deformable vessel mesh model (top left)
- and the device simulation procedure (bottom left)
- to the visualization of the simulated training environment (right).

We proposed a vasculature deformation model that relies on a Position-based Dynamics (PBD) approach [1]. This work presents an auto-adaptive calibration using Particle Swarm Optimization (PSO) algorithm on PBD deformation parameters and the vessels movement due to heartbeat.

Results

The simulator uses a novel calibration approach (PSO) with respect to literature, and it has a mismatch (root mean square error, mean error±standard deviation) of (0.26%, 0.23±0.13%) for deformation and (0.87mm, 0.71±0.50mm) for the aortic root displacement due to the heartbeat motion.



The validity and visual authenticity of the virtual system were evaluated by cardiologists (ten experts and ten novices). The experts reached a playtime of 171.1±111.2s and collision response of 5.0±8.0 for right coronary cannulation, while the novices reached a playtime of 83.9±46.1s and collision response of 15.2±42.1.

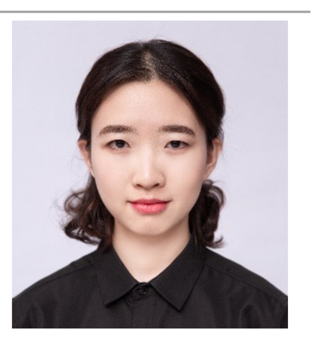
Discussions and Conclusions

The real-time and accurate performance of the simulator make this framework suitable for creating a dynamic environment for intra-operative path planning and control for robotic catheters.

Future work will be to develop a simulator with real-time path planning [2] for a medical robotic platform for endovascular catheterization such as [3].

Biography

Zhen Li



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References & Acknowledgment

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[3] M. H. D. Ansari, B. Farola Barata, F. Trauzettel, Z. Li, D. Wu, D. Dall'Alba, G. Borghesan, M. Ourak, V. Iacovacci, S. Tognarelli, J. Dankelman, E. De Momi, P. Breedveld, P. Fiorini, J. Vander Sloten, A. Menciassi, and E. Vander Poorten, "Proof-of-concept medical robotic platform for endovascular catheterization," in *Proc. of the 11th Conference on New Technologies for Computer and Robot Assisted Surgery (CRAS)*, 2022.

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