ARTHETA-0: An Innovative, Affordable, Approach to the Onsite, Rapid 3D Printing of Artery Stents, Parameterized to Fit Individual Patients' Needs

Connor Mitchell & Prabuddha Ghosh Dastidar, North Carolina School of Science and Mathematics, Durham, NC, US

Engineering Problem: Shortcomings of Stent Manufacturing

- Expensive methods like laser cutting (>$100,000 unit)
- Stents made using one-size-fits-all approach
- Stent fabrication is externally sourced (off-site)

Engineering Objective: Design and build a 3D printer that

- Has a novel motion system, specialized for stents
  - **Polar motion system** (r-, theta-, and z- axes)
  - **Horizontally static print bed** for more accurate prints and lower print failure rate
  - **Dual extrusion** for complex stent geometries
  - Elimination of cantilevered axes for mechanical rigidity
- Can be produced at affordable price (<$500 per unit)
- Implements a **Simplistic Fused Deposition Modeling** (FDM) system for on-site stent fabrication
- Uses custom-made ArGen software (G-code slicing → Deployment) and Modified Marlin Firmware

Results: Testing and Output

- Every subsystem has been proved to be mechanically viable through mechanical motion testing

Pre-slop Precision Based off Tech Specifications & Mechanical Design (ARTHETA-0 vs Traditional Cartesian)		
R-axis vs X-axis	Theta-axis vs Y-axis	Z-axis vs Z-axis
125µm* vs 125µm	2µm vs 125µm	25µm** vs 25µm

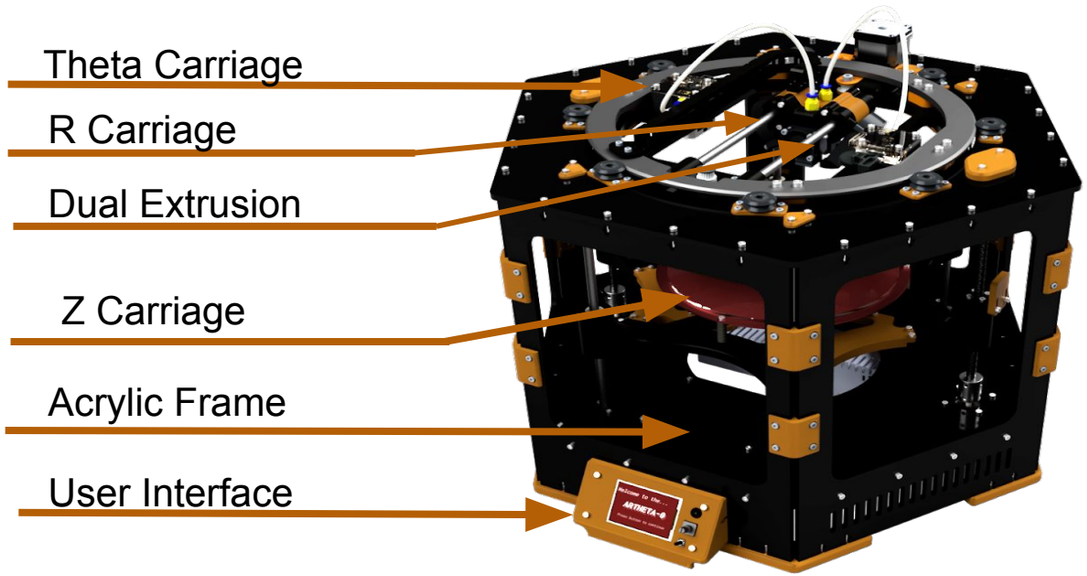
Charts and Tables by P. Ghosh Dastidar

*The effect of R-axis precision error in the ARTHETA-0 is negligible (unlike x-axis) because structure restrains R-error

**Due to reinforcements, Z-axis slop is much less than traditional printers, resulting in negligible effects on the print

Output: Thermoplastic Polyurethane (TPU), **bioresorbable**, **customizable** stents (>2mm diameter , 15µm total precision)

ARTHETA-0: Project Design & Prototype



Interpretations & Conclusion

- The ARTHETA-0 is extremely affordable at **$471**
- Can print stents that are **parameterizable** to patient dimensions, reducing post-stenting risks (ex. restenosis)
- Can be implemented **on-site** due to simple FDM system and non-extensive infrastructure (≈3 ft^3)

The Innovation of the ARTHETA-0 allows us to envision a future where doctors can use current medical scanning techniques to image a patient's arteries and receive a custom-fabricated stent within 2 hours of parameter input

Future Directions

- Utilize dual extrusion for more complex stents such as drug eluting stents
- Implement theta-axis bearing for ease of manufacturing
- Implement sheet metal frame for long-term rigidity
- Extend print materials to Polycaprolactone and Polylactic Acid for increased customizability on stent parameters such as rigidity/flexibility