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PROJECT PIPELINE

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OBJECTIVES

1. EXPAND DATABASE
2. EXPAND DATABASE + LABELS
3. **STENOSIS QUANTIFICATION**
4. AUTOMATIZE ALL THE WORKFLOW

STENOSIS QUANTIFICATION WORKFLOW

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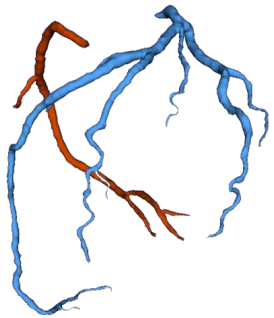
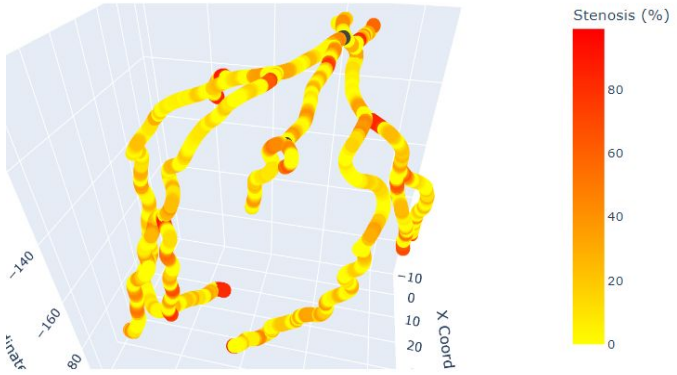
Segmentation (.mcs) → Centerline properties (.txt) → Stenosis code → Stenosis 3d representation



- **Px,Py,Pz**: point coordinates
- **Dfit:** diameter of the best fit circle in point P
- **Dmin**: diameter of the inscribing circle in point P
- **Area:** sectional area in point P

jupyter



materialise mimics
innovation suite

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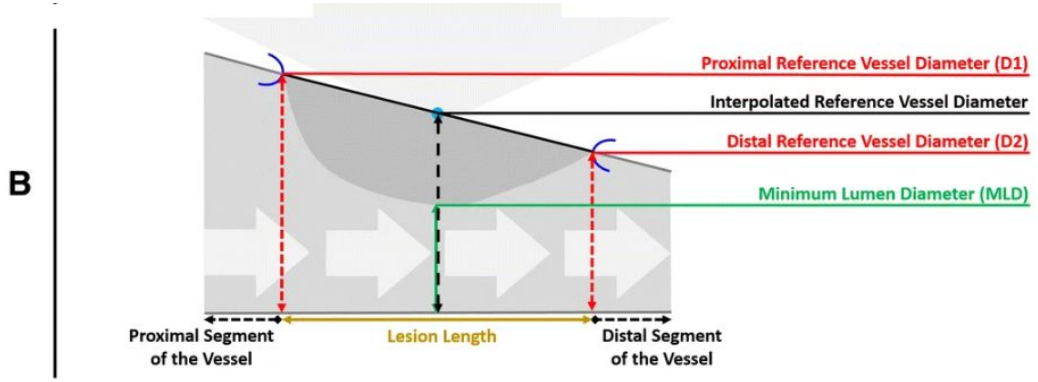
3. STENOSIS QUANTIFICATION

Percentage diameter stenosis (%DS) is a measure used to quantify the degree of narrowing or obstruction in a blood vessel due to plaque buildup or a lesion. It represents the percentage reduction in the diameter of the artery at the site of the lesion compared to a reference diameter in a healthy part of the artery.

- **%DS1** is calculated by averaging the proximal and distal reference vessel diameters (the diameters of the artery before and after the lesion).



$$Stenosis(\%) = \left(1 - \frac{d_{\min}}{\frac{d_{\text{prox}} + d_{\text{dist}}}{2}}\right) \times 100$$

Hideo-Kajita, A., Wopperer, S., Beyene, S. S., Meirovich, Y. F., Melaku, G. D., Kuku, K. O., Brathwaite, E. J., Ozaki, Y., Dan, K., Torguson, R., Waksman, R., & Garcia-Garcia, H. M. (2019). Impact of two formulas to calculate percentage diameter stenosis of coronary lesions: from stenosis models (phantom lesion model) to actual clinical lesions. The International Journal of Cardiovascular Imaging, 35(12), 2139–2146. https://doi.org/10.1007/s10554-019-01672-z

3. STENOSIS QUANTIFICATION

Variables adaptation

$$\text{Stenosis } \% = \left(1 - \frac{p}{\frac{d_p + d_d}{2}}\right) \times 100$$

- p: calculation parameter
  - Dfit: diameter of best fit circle
  - Dmin: diameter of inscribing circle (minimum)
  - Area: sectional area

  } possible p parameters
- d_d: distal reference valve
- d_p: proximal reference valve

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CODE - Functions

1 calculate_stenosis

Calculates the percentage of stenosis at each point along the artery.

Input: dmin, dprox, ddist
Output: % stenosis

2 get_reference_values

Determines the reference values (proximal and distal) for a given point (index) along the vessel.

Input: data, index, window_size o range1, range2
Output: dprox, ddist

3 create_and_visualize_3d

Reads the data from the .txt file, calculates the stenosis for each point, and generates a 3D interactive graph. (integrates the other two functions)

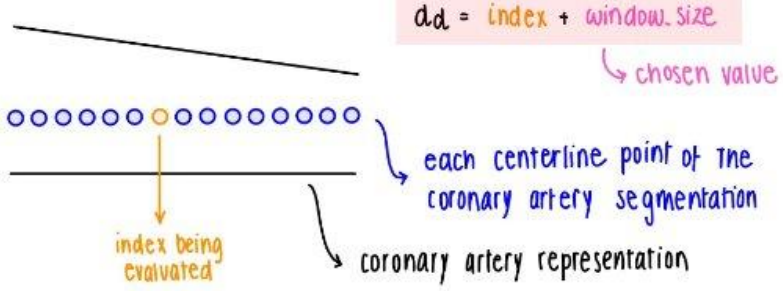
Input: file_path, branch_name, p (parametro de cálculo)
Output: 3D interactive representation

CODE

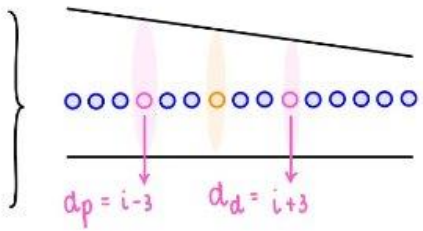
reference values calculation (d_d i d_p)

method 1. : Value

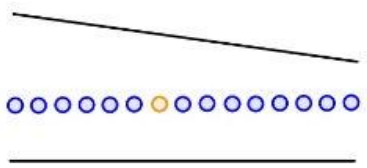
d_p = index - window_size
d_d = index + window_size
↳ chosen value



Example : window_size = 3



method 2 : range



d_p :

we make sure our position value is not negative

```
start_prox = max( index - range2, 0 )
end_prox = max( index - range1, 0 )
```

} then we choose the maximum value of parameter p between start and end

d_d =

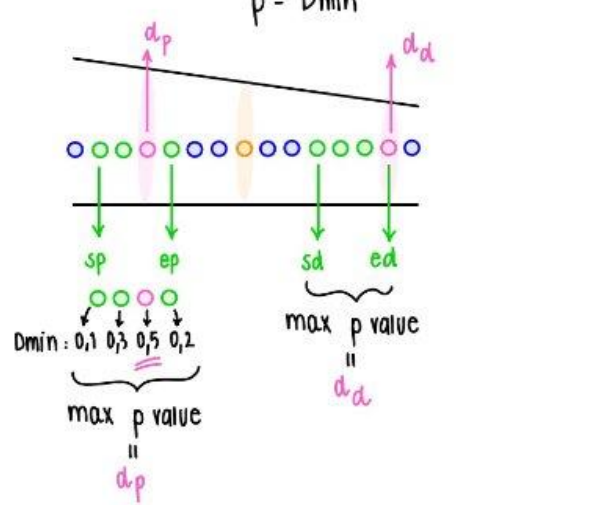
```
start_dist = index + range1
end_dist = min( index + range2 +1 , len (data))
```

} then we choose the maximum value of parameter p between start and end

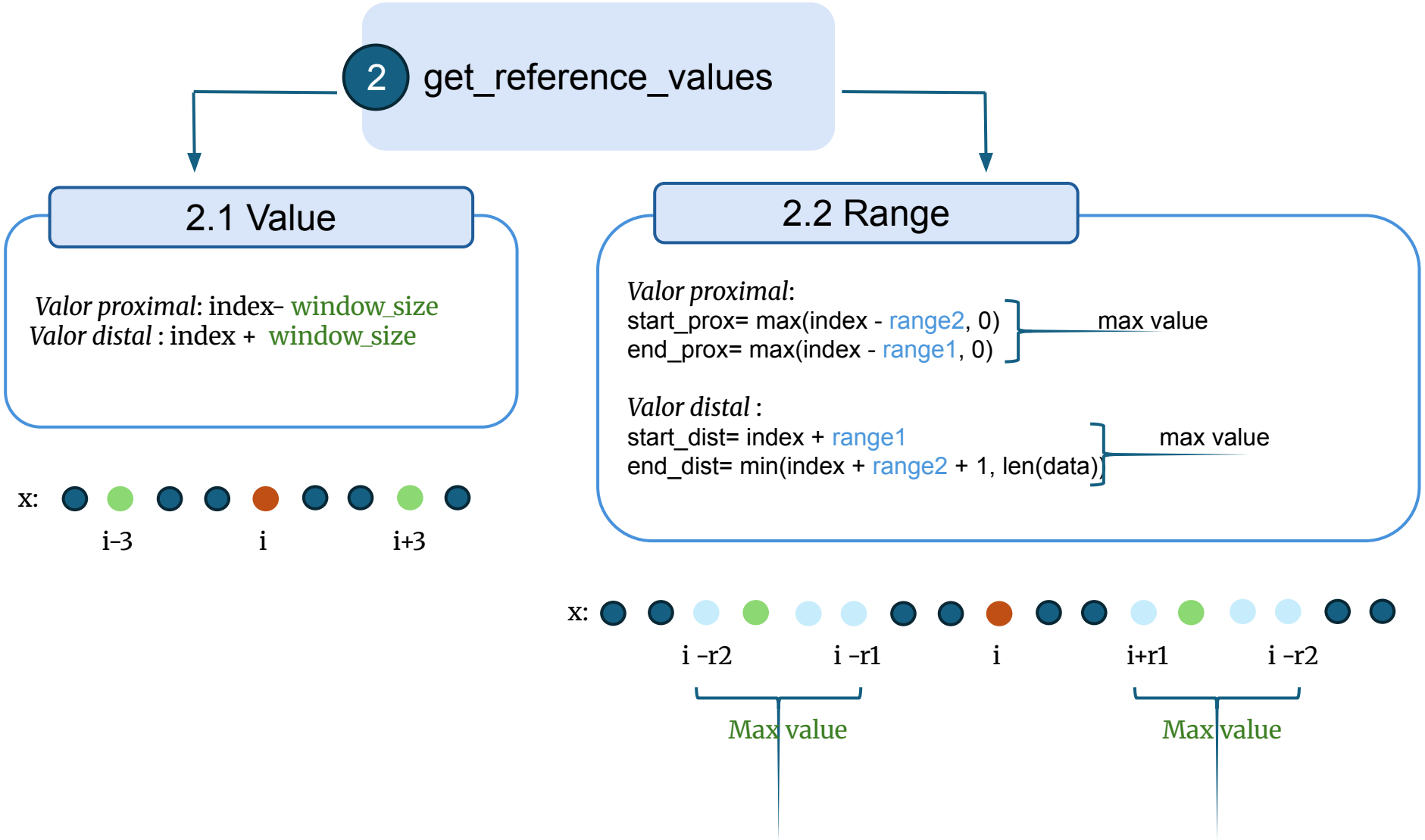
↳ we make sure our position is not bigger than the data lenght

Example : range 1 = 3 ; range 2 = 6

p = Dmin



CODE


2 get_reference_values
2.1 Value
Valor proximal: index- window_size
Valor distal : index + window_size
x:
i-3
i
i+3
2.2 Range
Valor proximal:
start_prox= max(index - range2, 0)
end_prox= max(index - range1, 0)
max value
Valor distal :
start_dist= index + range1
end_dist= min(index + range2 + 1, len(data))
max value
x:
i -r2
i -r1
i
i+r1
i -r2
Max value
Max value

CODE - Funciones

3 create_and_visualize_3d

Stenosis parameter can be changed

- **Dfit:** diameter of the best fit circle in point P -> index 12 (column 13)
- **Dmin**: diameter of the inscribing circle in point P -> index 13 (column 14),
- **Area:** sectional area in point P -> index 19 (column 20)

TRIALS

Trial 1:
- Apply the stenosis code to Case 4 Normal and Case 4 Diseased
- Stenosis representation for each combination of parameters

Trial 2:
- Apply the stenosis code to all cases
- Manually find the maximum stenosis value for all cases, without taking into account bifurcations and end branch values, as the result seems inaccurate.

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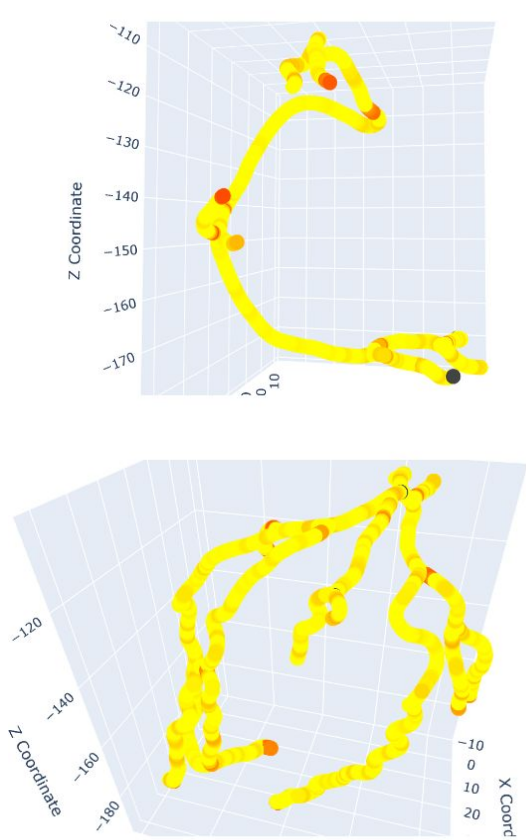
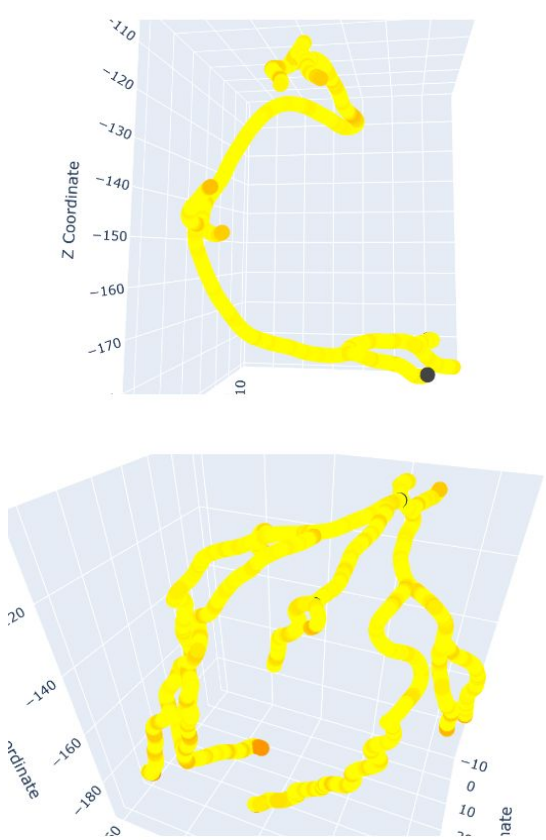
TRIALS – NORMAL 4

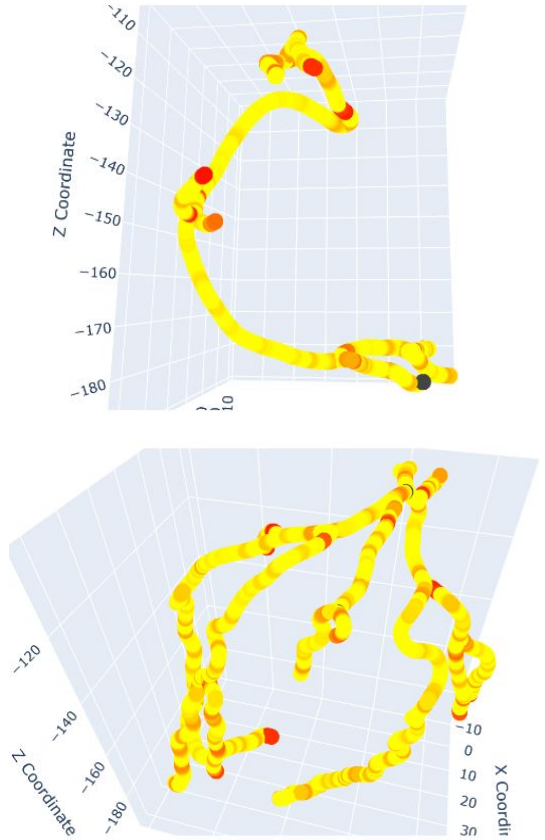
Value, Dfit

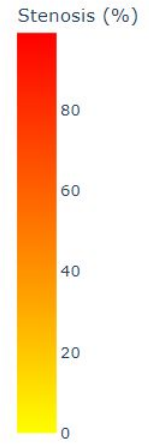


Value, Dmin



Value, Area





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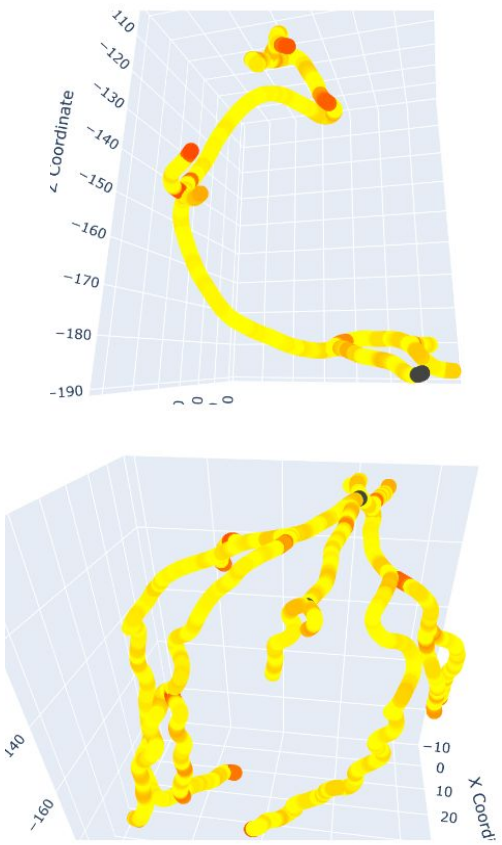
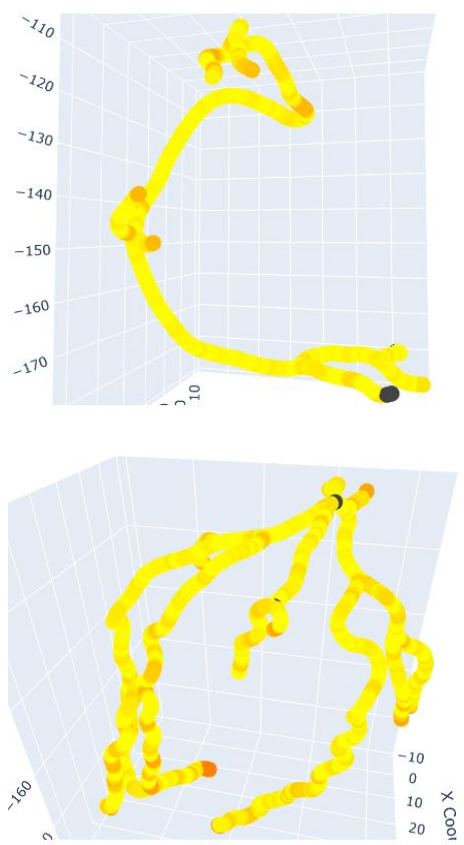
TRIALS – NORMAL 4

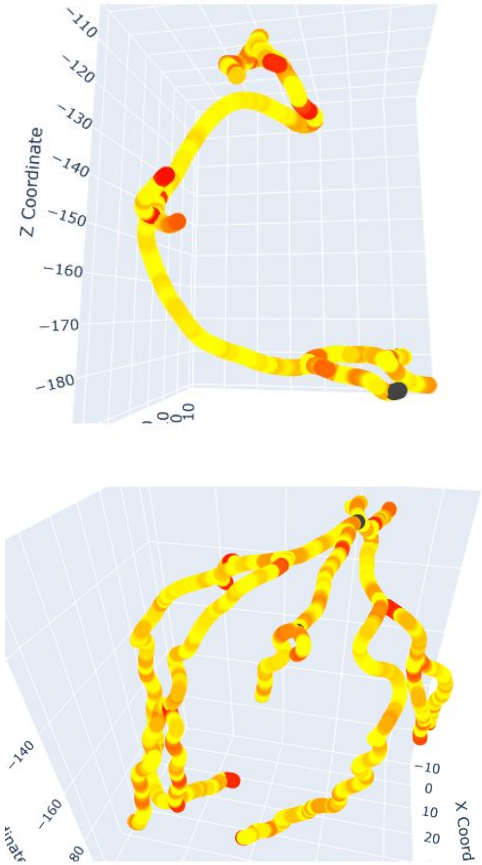
Range, Dfit

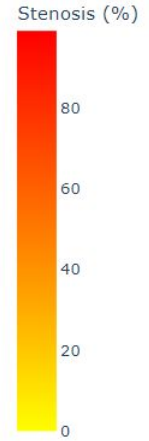


Range, Dmin



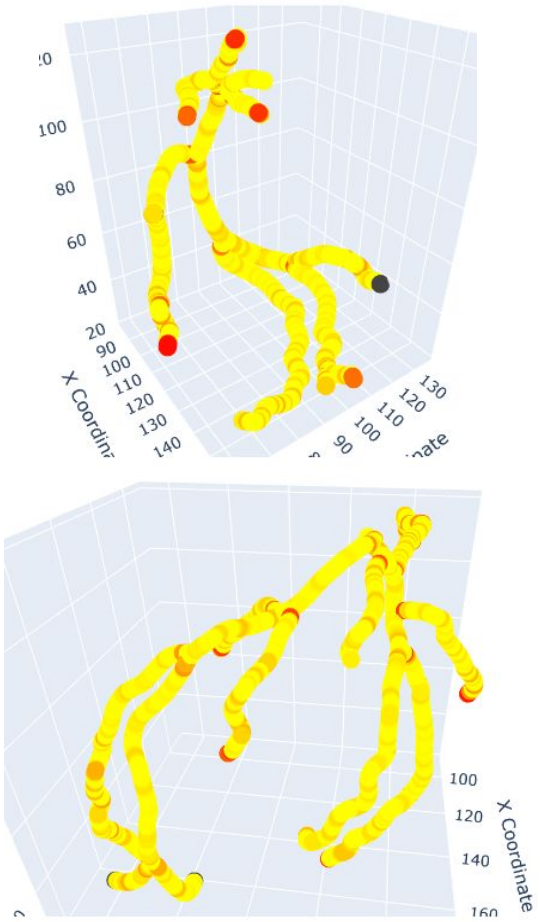
Range, Area



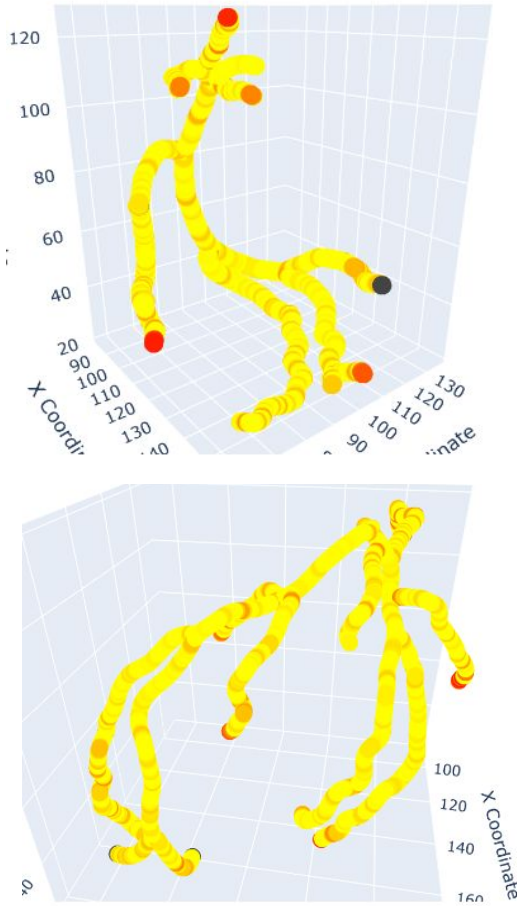


TRIALS – DISEASED 4

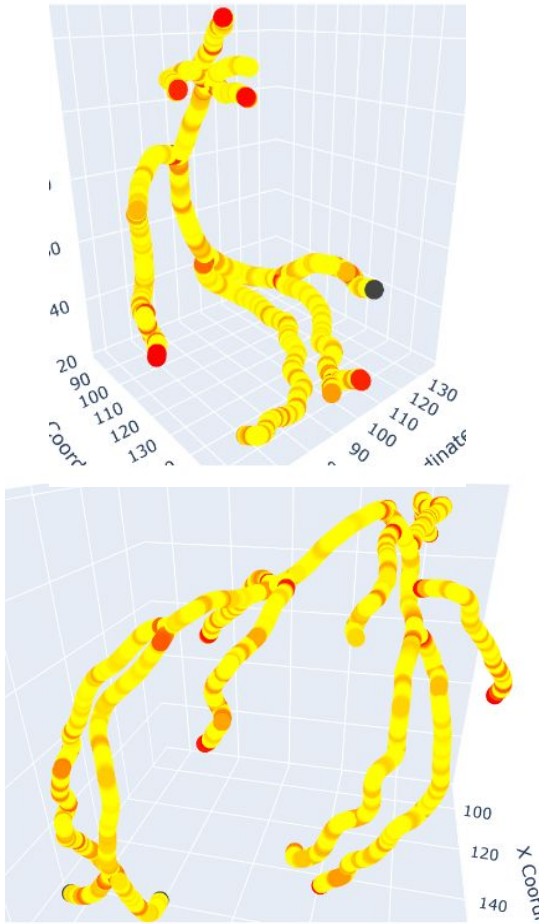
Value, Dfit

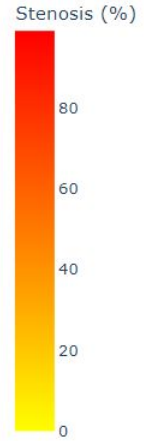


Value, Dmin



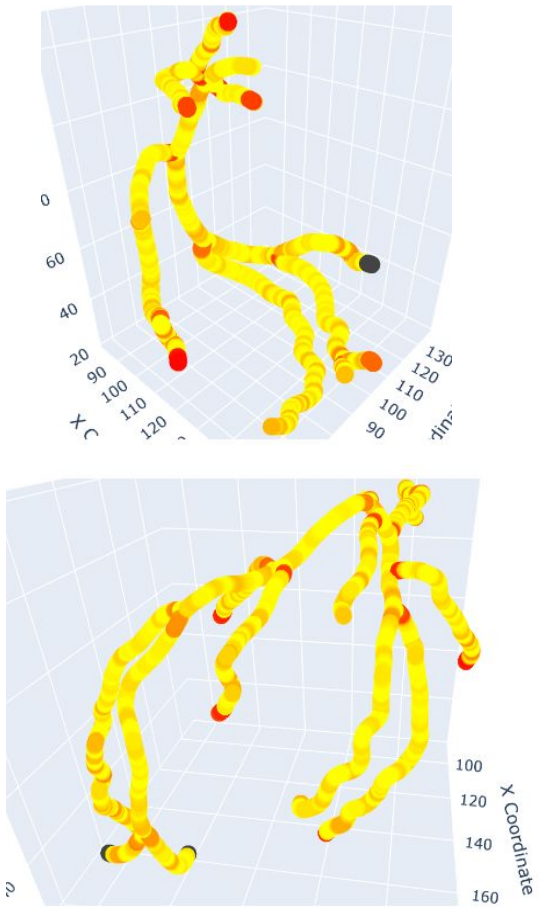
Value, Area



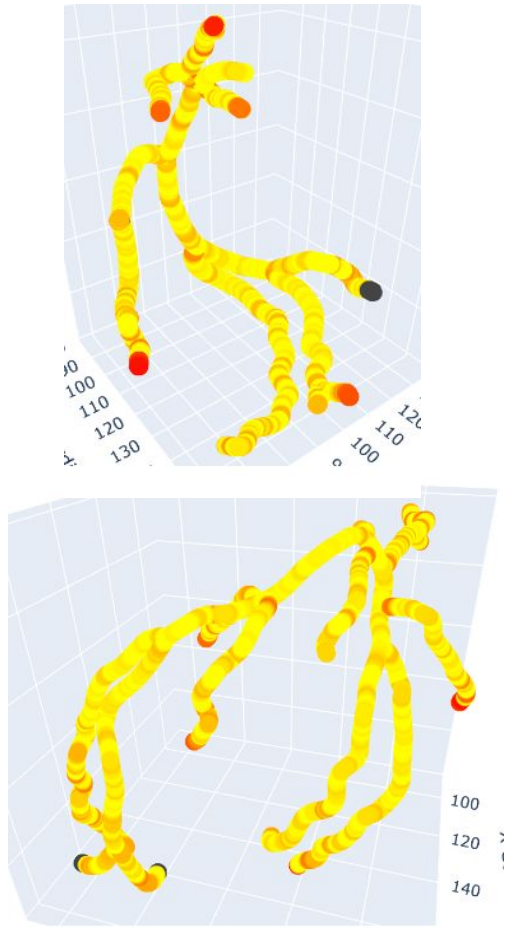


TRIALS – DISEASED 4

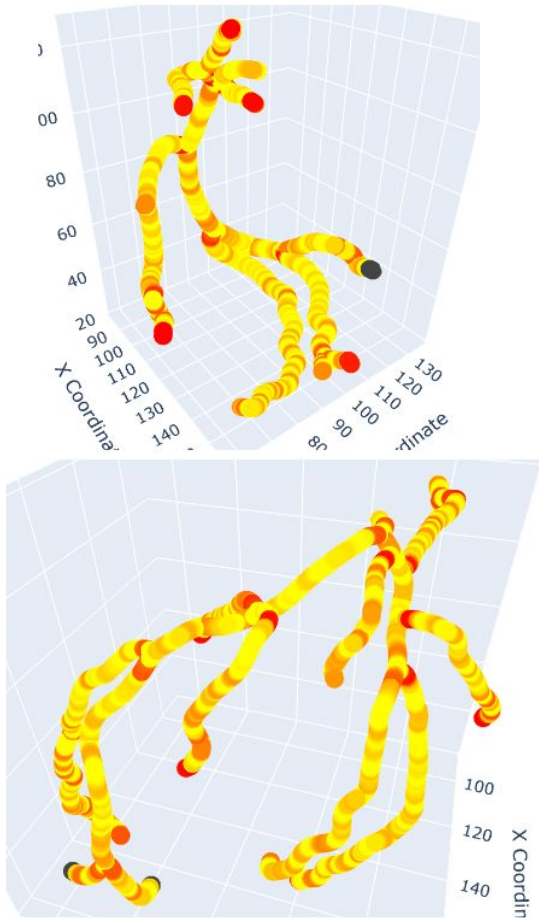
Range, Dfit

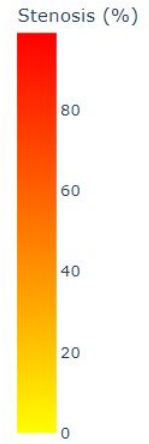


Range, Dmin



Range, Area





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TRIALS – ALL CASES

Reference method used: value

Case	Max stenosis value*					
	RCA			LCA		
	Dfit	Dmin	Area	Dfit	Dmin	Area
Normal 1	39,00	38,35	63.05	40,46	40,45 (diff)	63,41
Normal 2	33,67	35,73 (diff)**	56,35	23,60	28,00	43,13
Normal 3	33,16	28,53 (diff)	54,65	30,69 (diff)	44,34	53,29
Normal 4	25,58	20,75	44,39	39,70	39,61	63,53
Normal 5	37,11	37,15	60,46	19,27	38,03	38,44
Diseased 1	30,67	76,56 (diff)	53,05	41,10	48,96	65,4
Diseased 2	48,84	54,54	74,42	37,13	32,24(diff)	60,96
Diseased 3	37,55	44,01 (diff)	60,77	35,00	44,68 (diff)	57,98
Diseased 4	58,57	52,01 (diff)	78,82	78,02	59,97(diff)	95,38
Diseased 5	49,41	56,63	74,79	35,56	40,66	59,38

*Without taking into account bifurcation and end branch values, ** All max stenosis values where analyzed in the same coordinates unless marked as (diff)

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TRIALS – ALL CASES

Reference method used: range

Case	Max stenosis value*					
	RCA			LCA		
	Dfit	Dmin	Area	Dfit	Dmin	Area
Normal 1	39,44	41,94 (diff)	63,40	41,79	41,06 (diff)	66,09 (diff2)
Normal 2	35,04	41,91	60,25	36,53	28,23 (diff)	59,07
Normal 3	35,46	41,28 (diff)	58,21	35,24	45,44	58,14
Normal 4	26,96	24,02	46,27	42,69	43,58	68,67
Normal 5	37,65	39,84	61,19	21,01	39,00	40,91
Diseased 1	28,79 (diff)	79,44	59,40	45,16	51,02	69,81
Diseased 2	51,82	58,02	77,31	40,05	39,11 (diff)	63,95
Diseased 3	39,77	52,56 (diff)	63,28	38,22	49,86 (diff)	61,60
Diseased 4	64,33	51,46 (diff)	83,04	78,46	61,33 (diff)	96,53
Diseased 5	45,77	58,04	75,06	39,67	49,29	64,27

*Without taking into account bifurcation and end branch values, ** All max stenosis values where analyzed in the same coordinates unless marked as (diff)

INTERPRETATION

Reference values calculation:

- Value method gives lower stenosis values
- Range method gives higher stenosis values

Stenosis calculation parameter

- Dfit: high values of stenosis
- Dmin: lowest values of stenosis
- Area: highest values of stenosis

FURTHER WORK

- Sabiendo donde está la lesión aplicar formula estenosis
- Aplicar labelling para poder determinar punto de estenosis
- Automatización del workflow