PATH OPTIMIZATION OF UCLA FOR THE PHYSICALLY DISABLED

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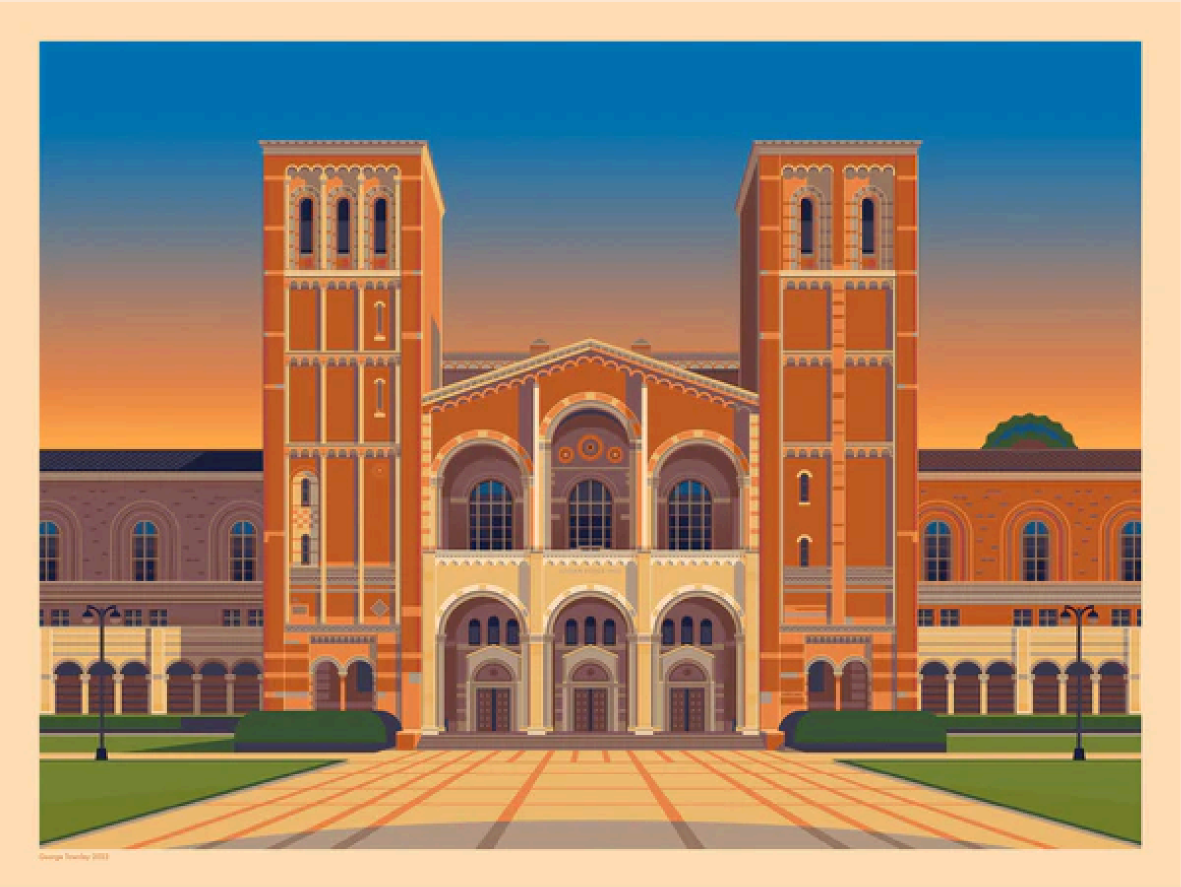

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MOTIVATION

- UCLA is notoriously hilly and difficult to navigate
- Physically disabled populations, including wheelchair users, crutches, etc, use lengthy detours
- How can we use networks to tackle the issue?
  - Map UCLA's campus and wheelchair accessible paths
  - Calculate shortest paths for wheelchair and non-physically disabled
  - Highlight the least accessible parts of campus using centrality measures

THE PROCESS

01 Optimize Data Collection

02 Design a Network

03 Shortest Path Algorithm

04 Calculate & Derive Insights

05 Propose Engineering Changes

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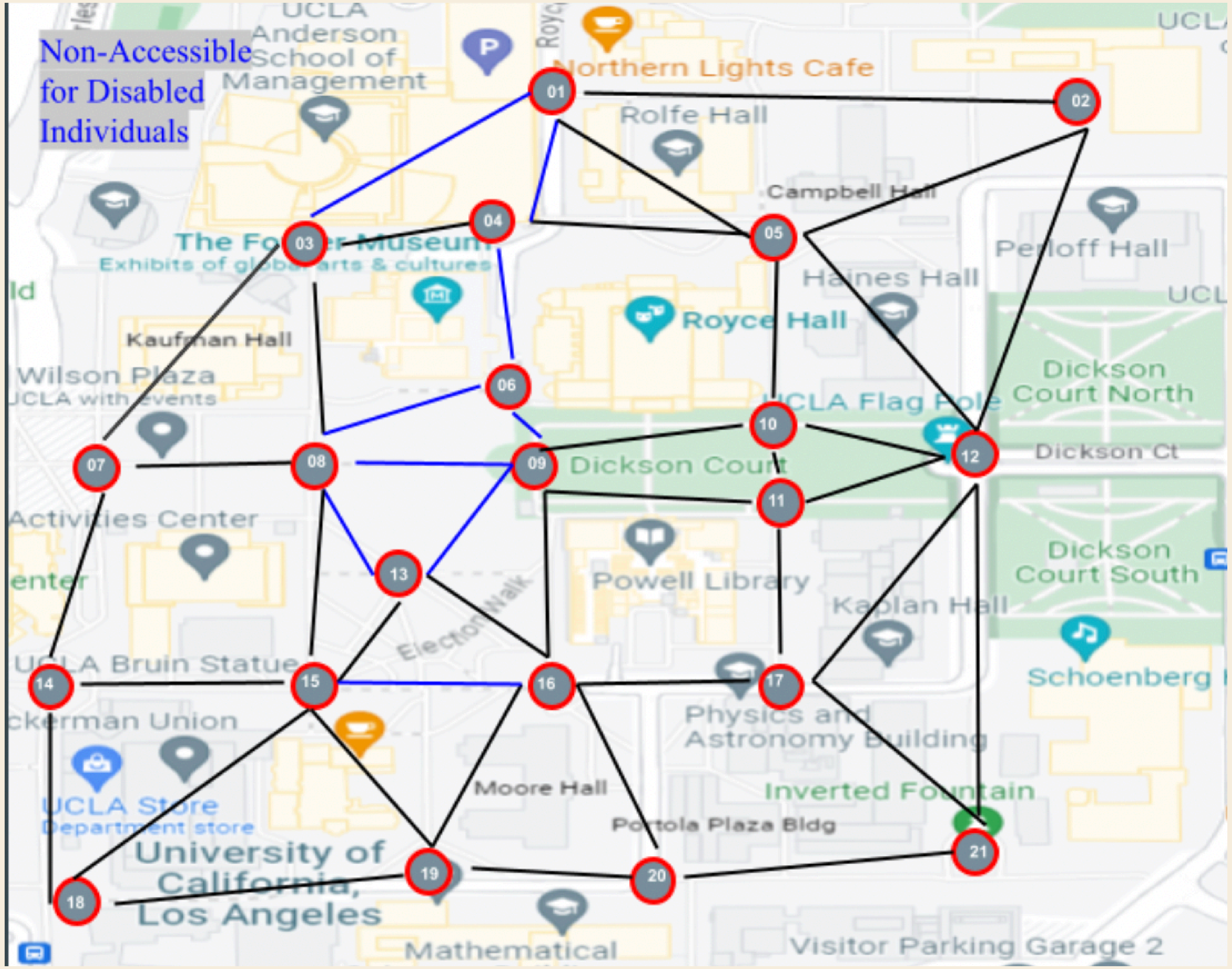
METHOD 1: MODELING

- Nodes: Selected key intersections on campus
- Paths: All existing connections between 2 nodes



DATA COLLECTION

- Simulated average walking and wheelchair speed to traverse through all possible paths, collected time
- Assumed 2 mph for disabled speed, 3 mph for non-disabled speed
- Assume natural gradient of pace decrease when walking up slope, also any route that requires above 35 degree incline is inaccessible for wheelchair
- Recorded times (in seconds, nearest hundredth) as the weight for each path

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1		97.28	205.66	51.28																	
2	85.34				106.75							169.41									
3	216.58			107.85			69.19	109.4													
4	59.84		92.34		110.39	105.37															
5		114.99		110.39						63.85		106.19									
6				97.41				93.97	130.63												
7			69.19					65.7						92.56							
8			109.4			93.97	65.7		101.49				64.58		113.4						
9						107.52		72.93		56.71	56.71		60.31			126.62					
10					63.85				56.71		30.34	43.33									
11									56.71	30.34		42.21					63.85				
12		171.38			106.19					43.33	42.21						110.97				205.89
13								54.25	63.55						68.35	101.93					
14							92.56								69.17			79.06			
15								115.71					91.41	59.17		98.7		194.01	133.45		
16									128.96				79.9		66.57		48.85		105.85	79.06	
17											63.85	111.37				45.85					88.11
18														79.85	179.74				86.7		
19															133.23	110.85		86.7		54.82	
20																79.06			43.93		145.41
21												212.11					88.11			145.41	

0: Non-disabled

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1		117.03			163.37				117.03			163.37				117.03			163.37		
2	108.13				200.43							283.96									
3				168.32			112.24	122.13													
4			167.36		86.58																
5	163.37	227.27		85.27						128.57		184.12									
6																					
7			127.08					71.44						107.12							
8			131.13				65.34								116.04						
9										161.04	152.49					98.94					
10					135.27				163.29		37.9	74.43									
11									159.16	37.9		74.43					199.99				
12		293.94			179.18					74.43	74.43						214.42				248.45
13															57.87	215.95					
14							108.89								110.04			87.29			
15								113.24					58.3	105.72					252.12		
16									98.94				191.72				50.35		173.62	95.17	
17											133.29	207.71				50.35					217.93
18														90.46							
19															239.1	196.67				108.65	
20																88.02			90.41		168.63
21												243.45					222.3			140.79	

1: Disabled

DATA COLLECTION

- Utilized JOSM to create Strava API heatmap as lines on map to identify traversable paths and nodes. Store coordinates
- Use QGIS API and Depth First Search to break down paths
- Create more nodes at regularied 10 meter intervals
- Attempted to utilize elevation API to calculate changes in elevation

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Bellagio Drive
De Neve Drive
Rieber Court
Rieber Walk
Charles E. Young Drive North
Charles E. Young Drive North
Royce Drive
Coral Tree Walk
Marion Anderson Hall
Portola Plaza
Charles E. Young Drive East
Bruin Walk
Bruin Walk
Westwood Plaza
Portola Plaza
Charles E. Young Drive East
Strathmore Place

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DATA COLLECTION

- Calculate travel times for each path based on elevation
- Identify wheelchair accessible paths according to legal guidelines (8% incline)
- Finalize complete network + wheelchair accessible network

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METHODOLOGY
DIJKSTRA'S SHORTEST PATH

- Dividing each path into 10 meters segments to account for curvature
  - Converting geodescic coordinates to meters
- Calculating travel time for each path with distance, speed, and slope (elevation change)
- Use Dijkstra's algorithm to calculate shortest path and record sequence of nodes

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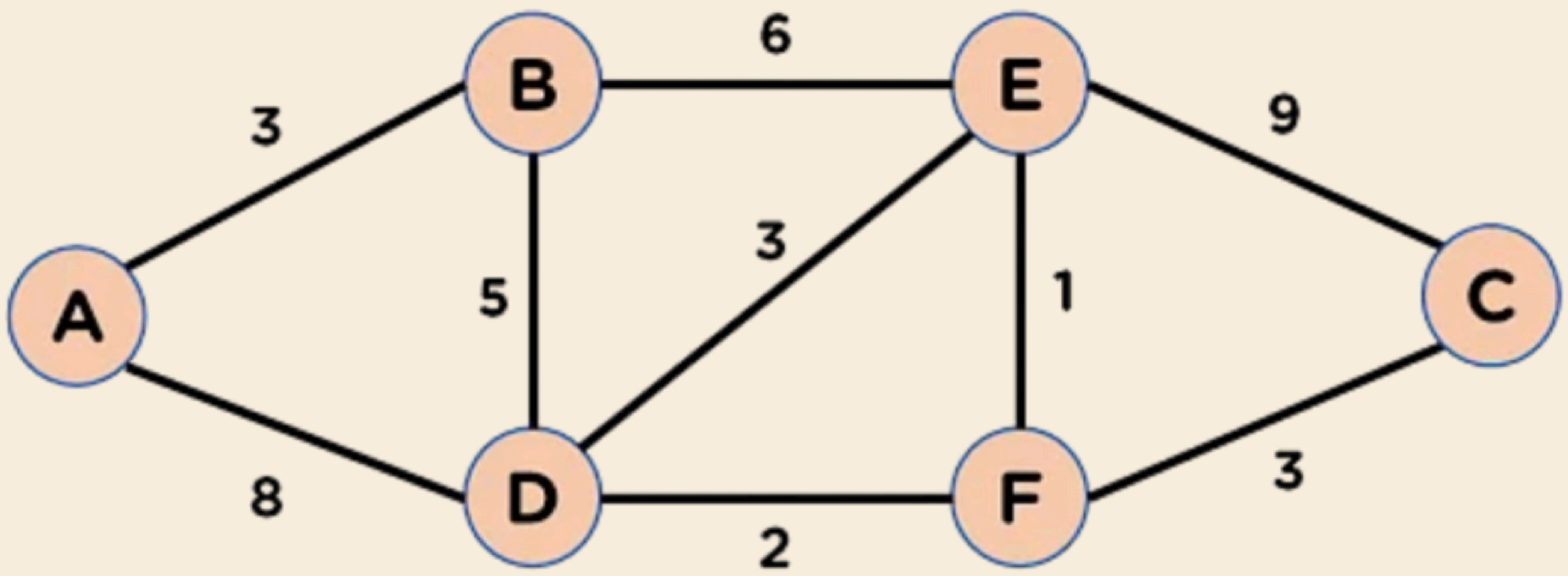
DIJKSTRA'S



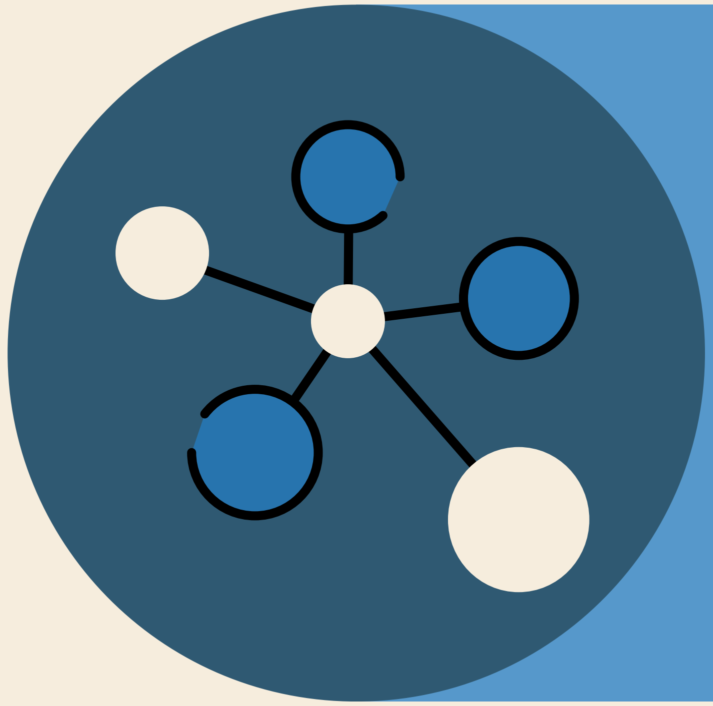
End / Start	A	B	C	D	E	F
A	0	3	∞	8	∞	∞
B	3	0	∞	5	6	∞
C	3	∞	0	∞	9	3
D	8	5	∞	0	3	2
E	∞	6	9	3	0	1
F	∞	∞	3	2	1	0

End / Start	A	B	C	D	E	F
A	0	3	13	8	9	10
B	3	0	10	5	6	7
C	13	10	0	5	4	3
D	8	5	5	0	3	2
E	9	6	4	3	0	1
F	10	7	3	2	1	0

LEAST RESISTANCE ALGORITHM

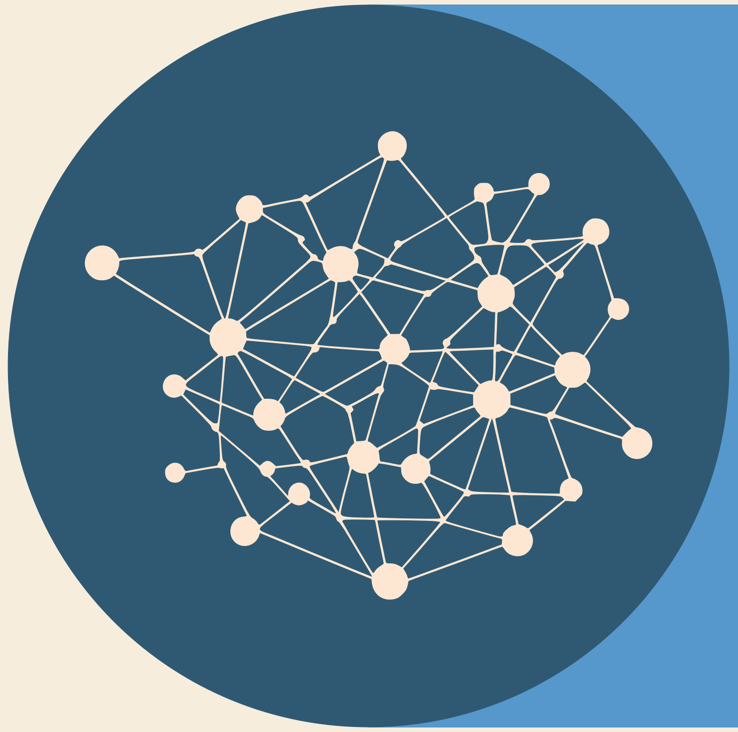
- Analog- electricity arcing through a non uniform material
- Steadily increase Voltage: amount of weight the algorithm allows current paths to overcome
- Construct & maintain two arrays, representing possible paths that can be achieved from start and end nodes, within the current voltage
- Algorithm iteratively explores all possible paths for both these arrays, building a collection of paths as the voltage increases
- Eventually, paths converge, representing the shortest route to get from start to end

CENTRALITY COMPUTATIONS



Betweeness Centrality

- Highlights nodes that are commonly used in shortest paths
    - Which parts of campus experience high traffic and at greatest risk of pidgeonhole
    - Which nodes are most crucial for wheelchair access



Katz Centrality

- Computes the relative influence of a node within a network based on immediate neighbors and the relative importance of those neighbors

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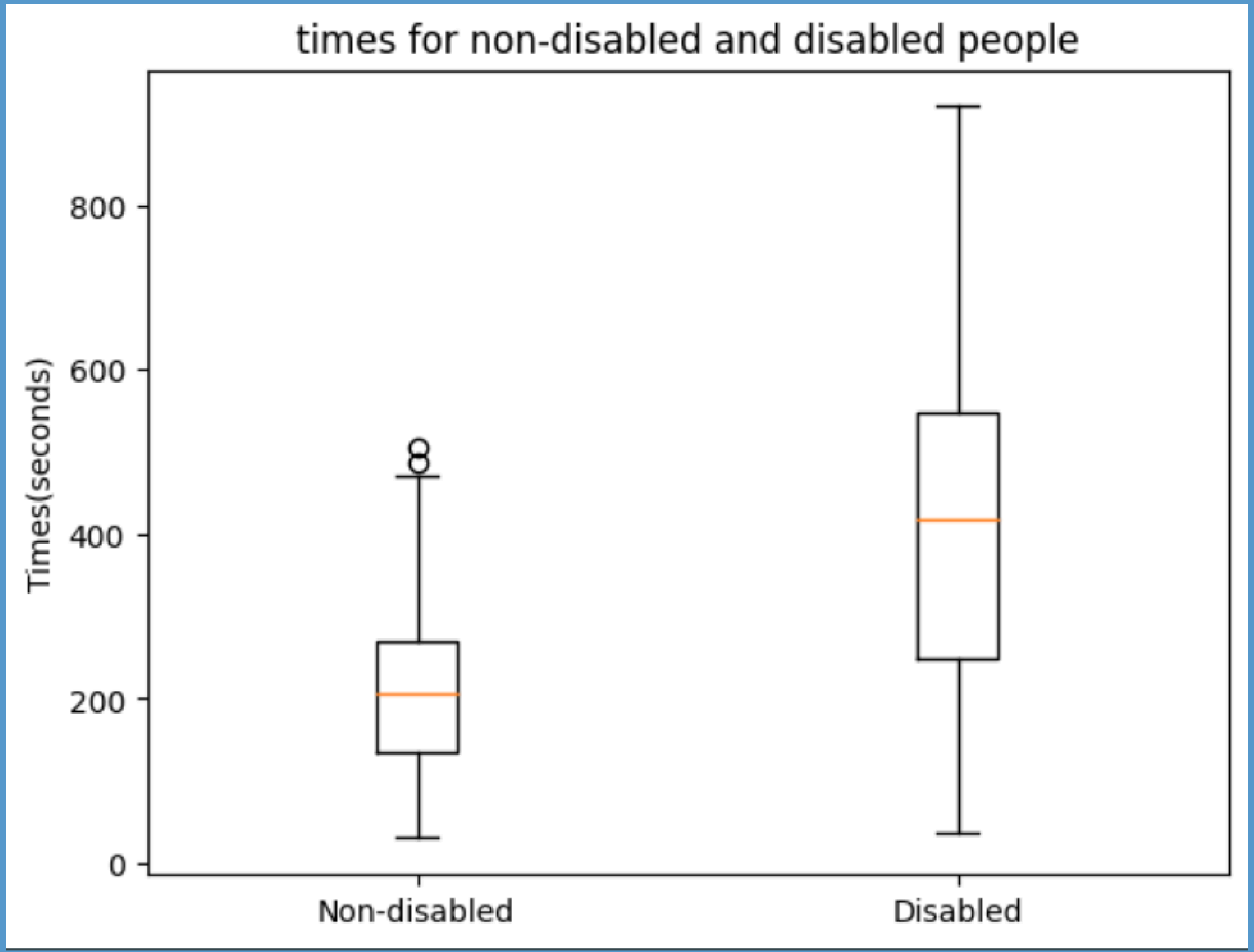
RESULTS

- 1290 by 1290 adjacency matrix
- Average times for disabled is much higher than non-disabled
- Betweenness Centrality:
    - Wilson Plaza: 0.1797
    - Pauley Walk: 0.1589
    - John Wooden: 0.1405



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RESULTS

	0	1	2	3	4	5	6	7	8	9	...	1280	1281	1282	1283	1284	1285	1286	1287	1288	1289
0			0.745599								...										
1			1.118402								...										
2	0.372801	1.491198									...										
3										0.372801	...										
4											...										

5 rows × 1290 columns

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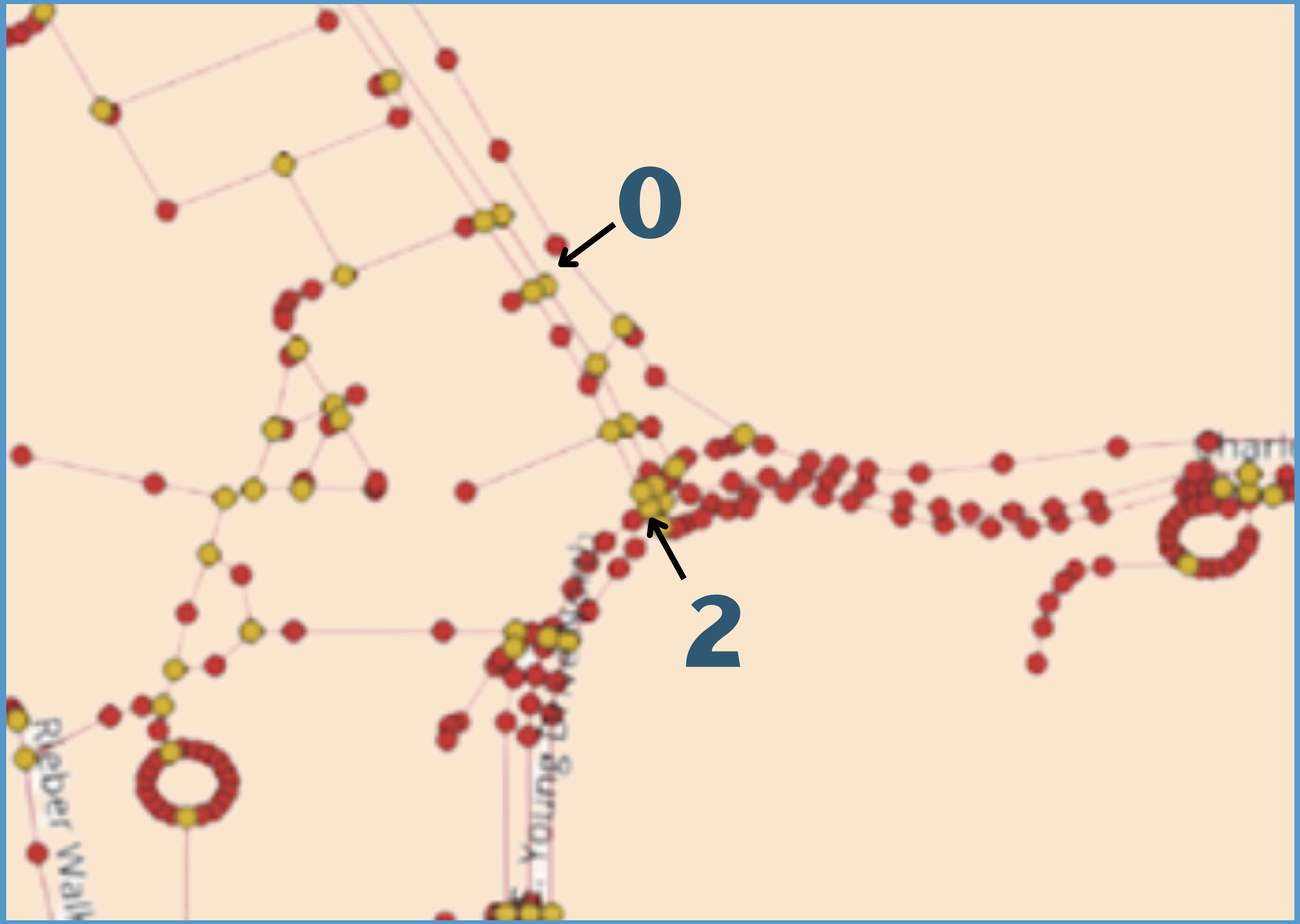
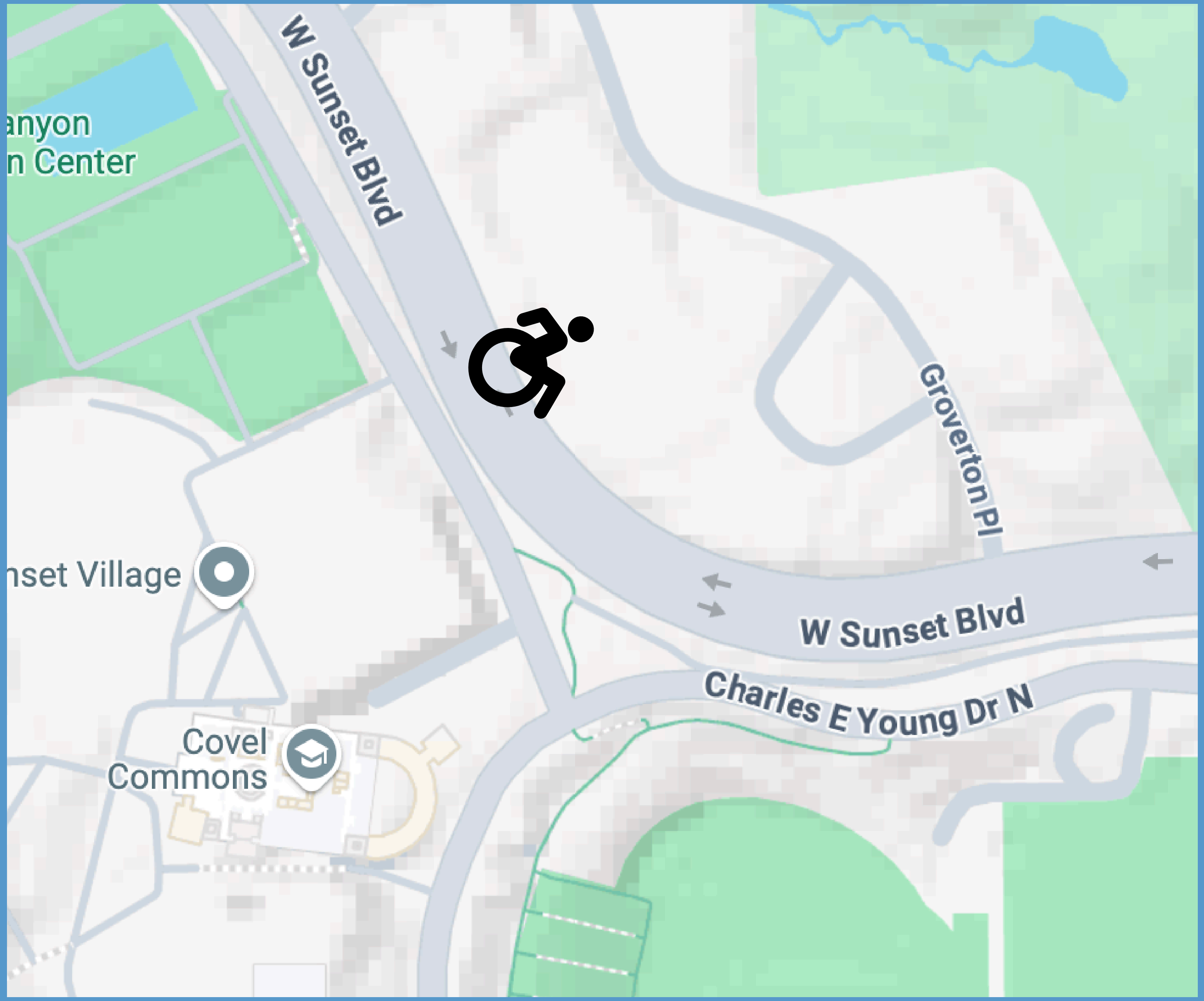


0
2



W Sunset Blvd
Groverton Pl
W Sunset Blvd
Charles E Young Dr N
Covel
Commons

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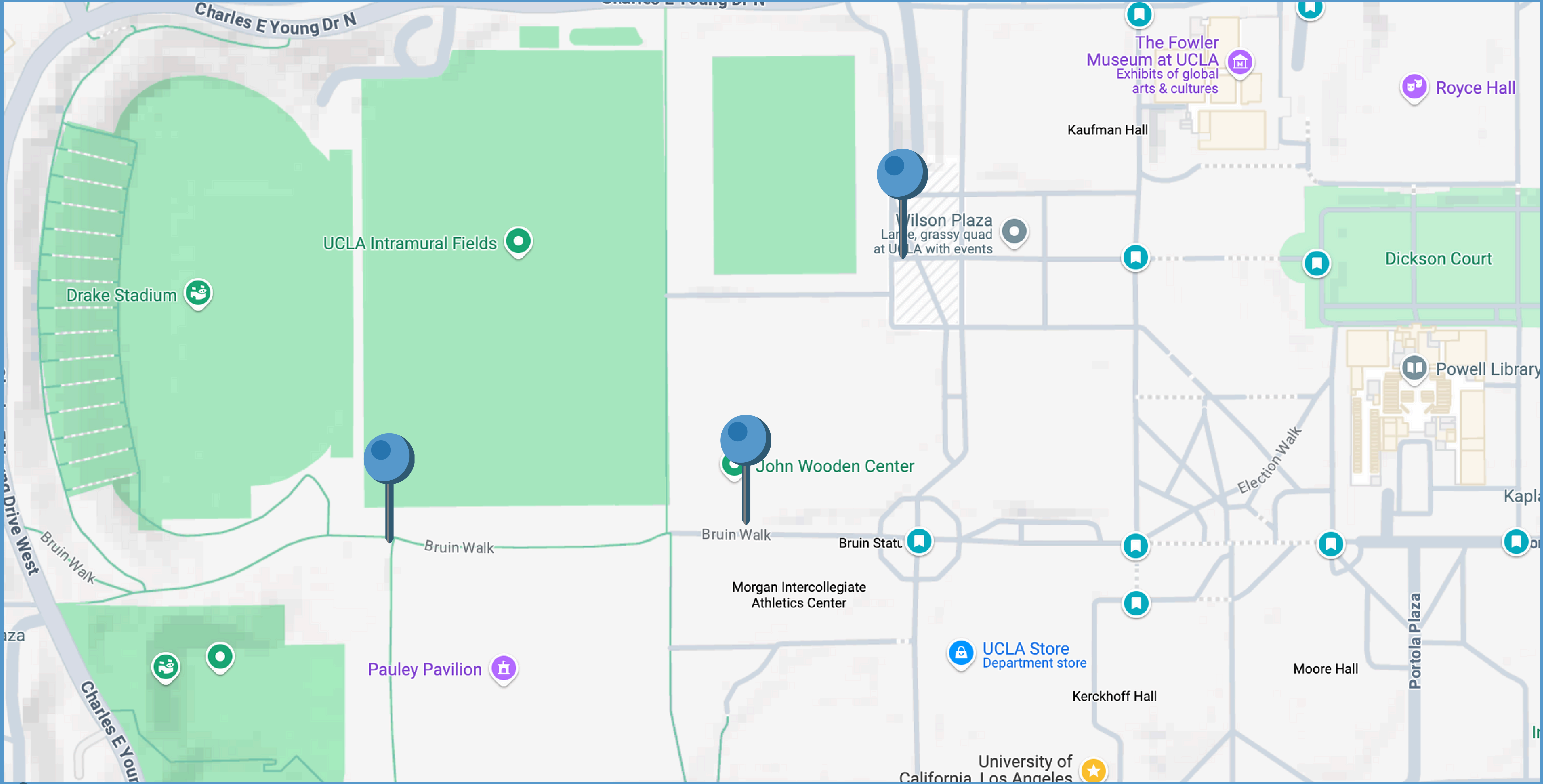
Charles E Young Dr N
UCLA Intramural Fields
Drake Stadium
The Fowler Museum at UCLA
Exhibits of global arts & cultures
Royce Hall
Kaufman Hall
Dickson Court
Powell Library
Election Walk
John Wooden Center
Bruin Walk
Bruin Walk
Bruin Walk
Morgan Intercollegiate Athletics Center
Pauley Pavilion
UCLA Store
Department store
Kerckhoff Hall
Moore Hall
Portola Plaza
University of California Los Angeles

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CONCLUSION

- Many areas of campus are inaccessible for wheelchair users
- Can identify crucial nodes using betweenness centrality
- Future steps
    - Tweak elevation API to determine inaccessible slopes
    - Expand boundaries of the network
    - Propose engineering solutions
    - Adapt to more university campuses. UniMap!

REFERENCES

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THANK YOU