

Engaging Computer Science Students in an Algorithms Course Using Real-World Data and Visualizations

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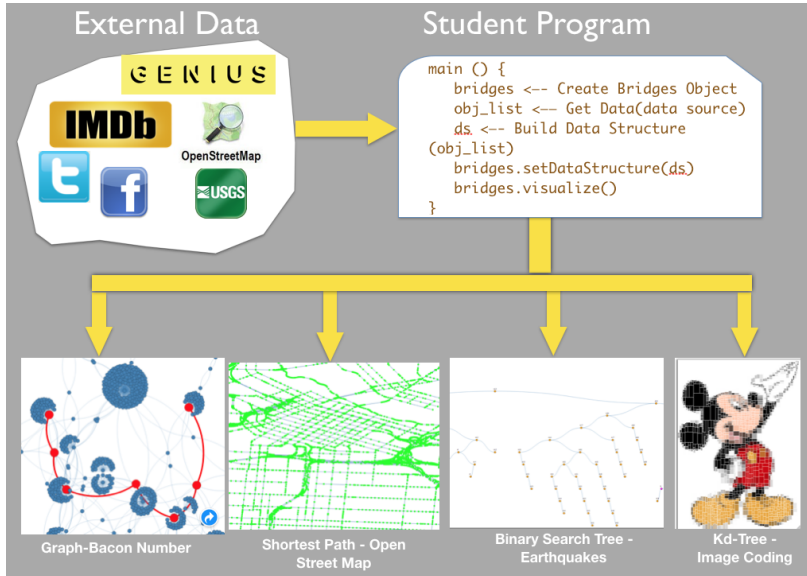
The University of North Carolina at Charlotte

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Engaging Students in Early CS courses Using BRIDGES

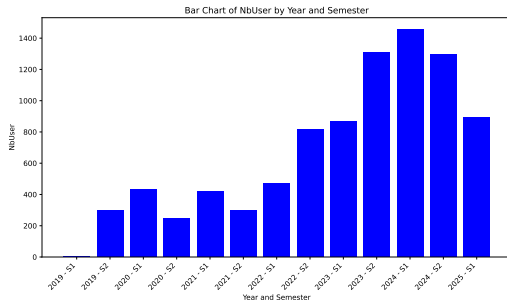
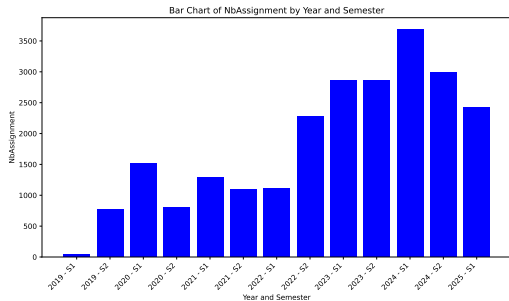
- A software toolkit developed and in use for over 10 years
- An API to facilitate engaging programming assignments
- BRIDGES provides **engaging input and output**
- Easily incorporate **real world datasets into routine class assignments**
- BRIDGES can produce **visualizations of student generated data structures, algorithm outputs/performance benchmarks, and support interactive games.**
- BRIDGES provides the **building blocks** for implementing data structures and algorithms, **not their implementations!**

What is BRIDGES?



Impact of BRIDGES

- Studies demonstrated knowledge gains in data structures
- Longitudinal studies showed performance of BRIDGES cohorts performed better in follow on core courses
- We have an active user base:several hundred students use BRIDGES each semester.
- Over 10,000 BRIDGES assignments completed over the years, 25+ universities, colleges, high schools have participated



ITCS 4114: Real World Algorithms

Junior/Senior Level Elective

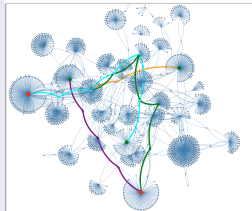
Module Content	Potential Assignments	Datasets
1. Data Structure Review, Math in Alg., BRIDGES setup	Linked list of US cities, Family Tree	US City data
2. Comp. Complexity, Sorting Alg., Quadratic and $n \lg n$ Alg. (Mergesort, quicksort))	Benchmarking Sorting Alg. (Quadratic vs N Log N Alg.)	Randomly generated
3. Graph Representations, Traversals (BFS, DFS)	DFS/BFS, Bacon Number/Path Computation	IMDB Actor Movies, Wikidata
4. Advanced Graph Algorithms (Topological Sort, Dijkstra's Shortest Path, Prim's Minimum Spanning Tree (MST))	Prim's MST using US Cities, Di- jkstra's SSP using OpenStreetMap data, Mountain Path using Eleva- tion data	US Cities, OpenStreet Maps, Elevation Data
5. Searching and Indexing: Binary Search, Search Trees: Balanced Trees (AVL, Red-Black, Splay Trees), Range Search, Spatial (Quadtree, K-d Trees, Bintree)	AVL Tree Balancing, Quadtree Con- str/Search on US cities	US Cities
6. Geometric Algorithms: Closest Pair, Convex Hull, Voronoi Diagram	Convex Hull of US Cities, Voronoi diagram	US Cities, Images
8. Dynamic Programming: Knapsack, War- shall's Transitive Closure, Floyds All-Pairs Short- est Paths	Least Effort (shortest path) on El- elevation Data Using Dynamic Prog Alg.	Elevation data

Assignment Output Visualizations

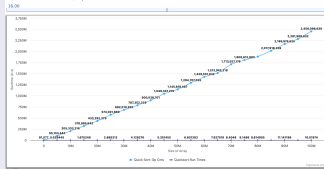


Bacon Number: IMDB Actor-Movie Data Graph

Actor Path Distances: Kevin_Bacon to Morgan_Freeman: 6 Kevin_Bacon to James_Cameron: 6 Clark_Gable to Annette_Beverly: 6 Clark_Gable to Helen_Sandhein: 6

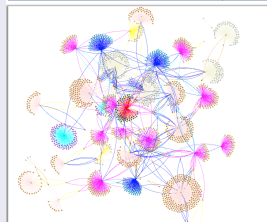


Quick Sort: Run Times, Operation Counts

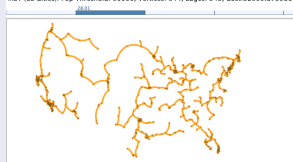


IMDB Graph with Level Ordering

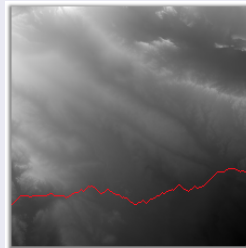
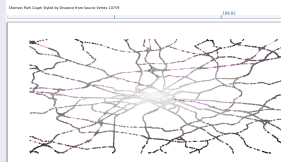
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MST (US Cities): Pop Threshold: 50000, Vertices: 944, Edges: 943, Cost: 32959.873583



Dijkstra's Shortest Paths Using OpenStreet Map Data



Clockwise from top Left: Plot of US Cities, Benchmarking quicksort runtime, op counts, BFS (Level Order), Least effort Path using DP (Elevation Data), Dijkstra SSP (Open Street Maps), Prim MST (US Cities), Bacon Number, Paths

Additional Information/References

- *BRIDGES Site*
- Paula Goolkasian, Kalpathi Subramanian, Erik Saule, Jamie Payton, “Measuring Student Performance and Readiness in Algorithms and Data Structures Courses”, *ACM Transactions on Computing Education*, Vol. 26, No. 4, May 2026.
- David Burlinson, Matthew Mcquague, Alec Goncharow, Kalpathi Subramanian, Erik Saule, Jamie Payton, Paula Goolkasian, “BRIDGES: Real World Data, Assignments and Visualizations To Engage and Motivate CS Majors”, *Education and Information Technologies*, Springer, Oct. 2023.
- Jason Strahler, Matthew Mcquague, Alec Goncharow, David Burlinson, Kalpathi Subramanian, Erik Saule, and Jamie Payton. Real-world assignments at scale to reinforce the importance of algorithms and complexity, In Proc. CCSC NE, 2020.