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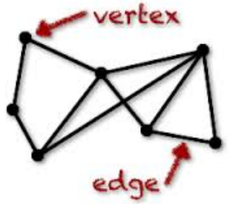

Graph Theory in Everyday Life

Research Experiences for Teachers
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http://etidweb.tamu.edu/hsieh/ResExp-Teachers

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Abstract

"We are currently preparing students for jobs that don't yet exist using technologies that haven't been invented in order to solve problems we don't even know are problems yet."
~ Karl Fisch

Computer Science and Engineering fields have many situations where a knowledge of graph theory is needed. The topic of graphical representation using vertices and edges should be discussed more within the K-12 public education classroom. This research shows how common problems can be visualized as graphs in the nature of vertices and edges and therefore a worthy topic for a problem solving strategy, not limited to the Computer Science field. A survey is created to further demonstrate the lack of awareness in this field of mathematics.

Research Objective

Hypothesis:

Graph theory is naturally and unknowingly used to process and analyze information.

Objectives:

- Find ten everyday scenarios and show in layman terms how they can be described with graph theory; that is, as sets of vertices and their connections with edges.
- Develop a survey to determine whether people are aware of the mathematics in graph theory behind the applications they use.

Methodology

In order to increase our knowledge of graph theory and the basics of vertex-edge graphs to be used as a problem solving tool we reviewed literature on the topic of graph theory in particular its existence or lack thereof in secondary education. Through this perusal of information a listing was created of applications that have an underlying premise with graph theory. We narrowed our list down to the objective ten scenarios by the definition of everyday life; that is, most relevant to many people of various demographics including education.

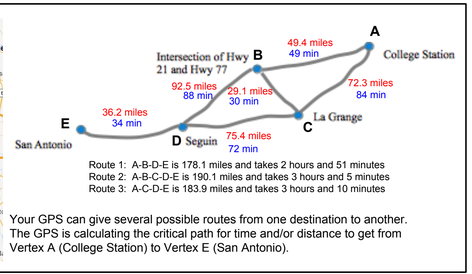
An analysis for the amount of exposure to the subject of graph theory involved identifying its existence in the secondary education curriculum through sources such as the Texas Essential Knowledge and Skills provided by the Texas Education Agency. We sought more information on secondary exposure by addressing advanced practitioners in the Computer Science and Engineering research lab; students who would more than likely have had an interest in course offerings with graph theory infused in the curriculum.

The objective to compose a survey includes the intention to quantify the knowledge of graph theory among the users of the everyday scenarios.

Results

Ten everyday scenarios with an underlying application of graph theory:

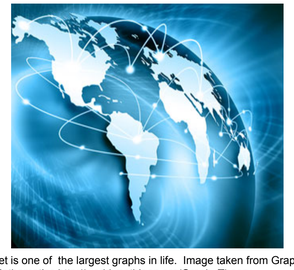
1. Using your GPS or Google Maps/Yahoo Maps, to determine a route based on user settings (quickest route/shortest route) or finding the cheapest airfare between two destinations. The destinations are vertices and their connections are edges containing information such as distance or airfare. The software finds the critical path (optimal route) based on the user settings.
2. Connecting with friends via social media or a video going viral. Each user is a vertex, and when users connect they create an edge. Videos are known to be viral when they have reached a certain number of connections/views.
3. School Districts developing bus routes to pick up students to deliver to school. Each stop is a vertex and the route is an edge. A Hamiltonian path represents the efficiency of including every vertex in the route.
4. The working of traffic lights; turning green and timing between lights. The use of vertex coloring graphs to solve conflicts of time and space and identifying the chromatic number for the number of cycles needed.
5. Planning and processing the preparation of a meal. The use of PERT graphs to plan a course of action for projects.
6. Using Google to search for webpages. Pages on the internet are linked to each other by hyperlinks; each page is a vertex and the link between two pages is an edge. PageRank and Googlebot are used algorithms to aid the connectivity process.
7. Shopping on Amazon or movies on Netflix. Relationship graphs are used to make recommendations for future shopping or films.
8. City planning to put salt on the roads when ice develops. Euler paths or circuits are used to traverse the streets in the most efficient way.
9. Visiting a zoo, water park or theme park and wanting to see certain attractions or devise an efficient route to see all of the attractions. A Hamiltonian path or circuit contains every vertex in the graph.
10. Examination on the spread of viruses/diseases. Vertex-edge graphs provide a visual for the network connection of those affected by the virus.



Route 1: A-B-D-E is 178.1 miles and takes 2 hours and 51 minutes
Route 2: A-B-C-D-E is 190.1 miles and takes 3 hours and 5 minutes
Route 3: A-C-D-E is 183.9 miles and takes 3 hours and 10 minutes

Your GPS can give several possible routes from one destination to another. The GPS is calculating the critical path for time and/or distance to get from Vertex A (College Station) to Vertex E (San Antonio).

Image taken from Graphy Theory World of Mathematics http://world.mathigon.org/Graph_Theory



The internet is one of the largest graphs in life. Image taken from Graphy Theory World of Mathematics http://world.mathigon.org/Graph_Theory

Results

These survey questions could be administered in order to determine whether people are aware of the mathematics behind the applications they use. The questions listed are paired as they pertain to a common application and a graph theory concept; however, the administration of the survey would not be formed in pairs as to lead an expected response. These questions were all formed as "Have you ever" questions with the intent of piquing the interest of potential survey participants.

1. Have you ever prepared a meal including the process of planning, shopping, cooking, and serving?
2. Have you ever used an activity graph or PERT chart to complete a project?
3. Have you ever gone to a zoo or an amusement park and used the map to determine the path to see all of the animals or ride all of the rides?
4. Have you ever determined a Hamiltonian path?
5. Have you ever performed a Google search?
6. Have you ever heard of the algorithm PageRank?
7. Have you ever used a mapping application such as Google Maps to determine a route to reach a destination?
8. Have you ever created a vertex-edge graph?

Clarifying questions pertaining to age and education are included in the survey for further analysis in identifying exposure to graph theory concepts.

The survey can be taken by scanning the QR code or visiting https://www.surveymonkey.com/s/23Y7SCW

Discussion

Texas curriculum identifies three courses as having mentioned concepts relevant to graph theory; Discrete Mathematics, Computer Science **III**, and Advanced Quantitative Reasoning. These courses are senior level courses attracting a small percentage of the population of students. The Texas Public Education Information Management System (PEIMS) indicates a 9% enrollment for the three relatively new courses during the 2013-2014 school year.

With further exploration we discovered that Computer Science and Engineering students did not recall the topic of graph theory presented to them until the initial years of their undergraduate studies. Our colleagues in the RET program were also unfamiliar with the topic especially towards their perspective courses in robotics and automation.

The survey application remains for those interested in furthering the research of this topic. There are many approaches to administer a survey as well as determining the intended audience. For our own curiosity we have recently implemented the questions using an online application as well as a quick response (QR) code.

We are hopeful in our plight to increase awareness of graph theory and its application within the secondary mathematics curriculum. We speculate this topic should be introduced earlier in a student's coursework and thus we have developed lessons that can be administered at various levels of secondary mathematics. These lessons are made available to instructors in public education.

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