Visualization Tools of Data Structures Algorithms – A Survey

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Abstract - In the area of computer science education, Algorithm visualization is the most popular tool used, while teaching data structure to undergraduate students. Using this tool student can easily understand concept of data structure and see visually how various operations performed on these data structure. This paper presents a survey on various visualization tool used in the literature from 2001-2013. Various technologies used to develop it, their benefits in learning data structure, limitations, year of publication and their authors.

Keywords — Visualization tools, Visualization tools of data structure, survey of visualization tools Visualization tools of Algorithms, Data Structures Algorithms.

I. INTRODUCTION

A data structure is important subject for undergraduate engineering students. How ever they found difficulty when they worked on its algorithm due to its abstract nature. Visualization tool makes data structure more easy and interesting. While using this tool they visually understand how algorithm works and how various operations (insertion, deletion, searching, traversal, merging etc) execute on data structure. Using this tool we can improve traditional style of teaching and also increase the interaction between learner and educator.

This study includes the various papers on various visualization tools in data structures algorithms and various platform used for visualization tool from 2001 to 2013. Various visualization tools in data structures algorithms used within this period of time are reviewed. All the papers which are discussed in the literature review were taken from IEEE explore and from Google engine. The survey was conducted on various visualization tools in data structures algorithms , various technology used do developed the tool and advantage of using tool in learning data structure. Before discussing review firstly we discussed what are algorithm visualization, its history, and its need.

A. Algorithm Visualization

As named suggests algorithm visualization is visual illustration of algorithm or program in static or dynamic 2D or 3D format. This method is used to give review of operations, data and semantics, and then generate dynamic graphical representation of those summaries. This is intended in a way that it supportive in understanding, evaluating and debugging program for user. Graphical view is used to represent internal data structure which is implemented in the program and these graphical representations is able to show better understanding of program to user as it shows the execution step by step and users are able to discover the principal description of the algorithm.

The history of algorithm animation and visualization is extended from past two decades. Earlier it started in 1966 and was created by Ken Knowlton at the Bell Telephone Laboratories. In early 80s the major development of algorithm visualization was started.

II. LITERATURE SURVEY

The main purpose of this paper is to present a survey on visualization tools in data structures algorithms used in recent years. Search was made on IEEE explore and Google, about 65 papers are downloaded out of which only 17 papers left after content filtering. Keyword used to search were data structure visualization tool, teaching learning tool of data structure and visualization tool of data structure. We present a wide literature survey in which all the papers are arranged in a descending order of their year of publication. Robert Meolic(2013), In this author present a approach to study sorting algorithms in mobile. The algorithms are represents in two forms i.e. pseudo-code and graphical display. Gnome Sort, Insertion Sort and Quick sort algorithms are implemented on smart phone as application. for developing application we use C++. [1]

Alhosban Fuad (2012) et al. This paper discussed an interactive visualization tools named DSL in which visualization is integrated with audio. For developing DSL tool java is used. The DSL (data structure learning) tool, have three main components named: Basic Objects, Nodes, and Integration of audio with visualization. [2]

Crescenzi Pilu, Malizia Alessio, Verri M. Cecilia, Díaz Paloma and Aedo Ignacio (2012), In this paper author focus on the full integration of AV (algorithm visualization) movies with the teaching material of data structure. In this they also compiled the results of AV movies use in teaching both from a student appreciation and according to student performance in test or exam. Students considered the AV movies a useful tool for self study and studying the material covered by the lecture notes. To develop AV movie, Algorithm visualization system is used called AlViE, which is a

post-mortem tool. This tool has three parts (1) a visualization player, (2) a graphical input developer that allows the user to create new input (3) a Java class library. [3]

Adamchik Victor (2011), In this paper author vision is to design a pen based computing environment in which student itself draw the data structure using tablet and stylus. For this they have to develop the interface, and this interface having four key parts: 1) stroke recognition and beautification, 2) the association of strokes to an underlying domain-dependent data structure, 3) the animation of algorithms, and 4) the verification of algorithms. [5]

Anghel Traian, Florea Adrian, Gellert Arpad (2011), In this paper author discussed e-Learning system, Education Management Tool (EDM), the purpose of enhancing traditional teaching style and examination methods, without replacing them.EDM tool have three parts e-learning, e-testing, e-management. The tool used in development is ASP.NET (.aspx) server pages, combined with AJAX javascript technologies and for database Microsoft Sql Server 2008. A con of this is database is not protected from attackers. [6]

Jin Bingyao, Jin Mingmei , Xue Xiaoqing (2010), This paper has given description about algorithm animation and its related features. This paper has also mentioned the concise history of algorithm animation. In this they review the various education experiences of algorithm animation and also suggest some design to improve its efficiency and effectiveness. In this Future plans including develop a new algorithm animation system and perform an experimental study to calculate its pedagogical effectiveness. [7]

Rajala Teemu, Kaila Erkki, Salakoski Tapio, Laakso Mikko-Jussi (2010), In this paper author create a visualization tool named "TRAKLA2". It is a learning environment, based on the visual algorithm simulation and visualization framework Matrix. In this author evaluate that whether it is effective to study about data structures and algorithms or not. In this they also evaluated that use of this tool will enhance learning experience of students or not. Grouping with another student while using this tool, will not be giving any extra benefit in learning. [8]

Vírseda Rafael del Vado (2010), In this paper author discussed an interactive visualization tool, which will be helpful for teaching purpose. The principle benefit of such software is to facilitate computer science students to hold on target procedure in their studies, group assignments and medium of communication between them and teachers. The technology used to design the tool is java. [9]

A. Korhonen , Mikko-Jussi Laakso , Niko Myller (2009), In this author study the use of algorithm visualization tool in group learning. For this they used ET (Engagement Taxonomy) and they consist of six levels of engagement between the visualization and the user. These six levels are No viewing, Responding, Changing, Constructing, and Presenting. In this they suggest that ET and group learning are grouped together but in controlled manner to have better outcome of learning data structure. [10]

Juaidu Sahalu (2008), Author has conducted study on how media-rich animations are helpful for computer science student to learn and have applied several algorithms in online data structures, and for this author have created Ellis's model. In this they also explain various ways to create effective algorithm animation. [11]

Demmings Brian, Shakshuki Elhadi, Müldner Tomasz (2007), This paper has discussed the ideal model implement by an author The AETA means Algorithm Explanation Teaching Agent worked on the Structured Hypermedia Algorithm Explanation. . The intelligent agent has better understanding about Algorithm Explanations. [13]

Chanslip K. and Oliver R. (2006), In this author implement a visualization tool named VIDSAA, Visualization in Data Structure and Algorithms. In this tool they covered data structures like Lists, Stacks, Queues, Trees, Sorting & Searching and Graph. There are total 55 animations. In this they visualized the data structure using programs and flow chart representation. [14]

Hendrix T. Dean, Cross H. James, and Barowski Larry A. (2004), In this paper author discussed various software and system that was used in developing data structure animation and visualization. They proposed framework have been implemented that allows the environment of a lightweight IDE in which we design the dynamic data structure visualizations. [18] Lawrence Ramon (2004), In this author involve new way to learn data structure using the concept of competitive gaming. While programming game the students should learn advanced concept of data structure and programming. [19] Colaso Vikrant, Kamal Aejaaz, Saraiya Purvi, North Chris, McCrickard Scott, and Shaffer Clifford A. (2002), In this author suggest, while teaching and learning data structures, we combine both visualization and text. Students are not satisfied with standard text materials, but visualization alone can lead to gaps in knowledge. Although visualizations are very helpful for students and it will support and motivate them to learn new topics. [22]

Hundhausen, C. D., Douglas, S. A., Stasko, 1. T. (2002), In this author explain the concept of AV (algorithm visualization), how they works and how we increases the effectiveness of AV? In this they discussed various issues of not using AV tool by students and educator. We used AV in lecturer, self study, for assignments, for test, for group discussion. Various techniques to evaluate the AV effectiveness are programmatic, analytic and empirical. [21]

Chen Tao, Sobh Tarek (2001), In this author implement a visualization tool of commonly used data structure and their operations. In this tool they also include animation of algorithms written by user/ student. For developing this tool java is used, AWT and Swing packages of Java provide general components for creating GUI. For animation of algorithm, a lexical analyzer and parser are used. [23]

III. RESULTS AND DISCUSSION

A survey was conducted to review the papers on various visualization tool of data structure used in recent years. A total of 17 research paper has been cited to gather the information about visualization tool history.

From the year 2001 to 2005 the maximum worked are done on basic data structures (like array, linked list, stack, queue, tree and graph) and its operations (insertion, deletion, searching etc). In these visualization tools user interaction is less and no control on animation of algorithm. The student's dedication towards visualization tool is less. The

development platform used for visualization is JavaMy. An AWT and Swing package of JavaMy are used for GUI and for algorithm animation lexical analyzer and parser are used. For dynamic visualization lightweight IDE is used.

From the year 2006-2008 another tool are used named VIDSAA and Ellis's model. In this period e-learning also come in trend. In this period apart from basic data structure recursion, sorting, searching algo, AVL, heap, B-tree and graph shortest path algorithms prim's and krushkal algo and spanning tree algo are also implemented. The technologies used in these periods are java, java applets, JavaScript, Ajax, ASP.NET 2.0 and SQL server 2005 and 2008 as backend database.

From the period of 2009- 2010 the tool of visualization is more user friendly, efficient and interactive. User has more control on visualization and animation speed. In this period worked done on all previous algorithms and additional hash table. The technologies used in these are ASP.NET (3.0, 3.5), Ajax, flash, JavaScript etc and SQL server 2008- 2010 as backend database.

In the period of 2011- 2013 the visualization is integrated with movies and audio instruction. Now mobile learning come in fashion for data structure and in 2013 sorting algorithms application is developed for smart phones. No worked is done on red-black tree, R- tree, BQR-Tree and implementation of pen based visualization environment.

Mobile learning data structure is good for undergraduate computer science students. algorithm sorting application for smart phones is very effective to learn the concept of sorting algo. but still it is complex another data structure like AVL, B-Tree, Red-Black tree etc. [1]

The visualization is integrated with audio instruction to increase its effectiveness but due to less time author didn't implement AVL tree, B-tree and graph algorithms. [2]

The integrating algorithm visualization (AV) with movies is highly appreciated by the undergraduate students of data structure, but student wants audio comments on these movies. [3]

The interactive and efficient visualization tool where student can draw data structure using stylus on tablet. For this pen based environment of visualizations is proposed and system design is done but its implementation is still pending. [5]

The EDM tool used in university to enhance the traditional style of teaching and examination but database of EDM tool is not secure. [6]

In this author discussed about visualization history and it's also explained various features that make visualization tool more effective and interactive. [7]

The case study on TRAKLA2 algorithm visualization tool and the student tell that his/her performance is increased using this tool but grouped working didn't give extra benefits. [8]

The author implements an interactive tool of visualization and they performed hypothesis on the tool in controlled and non controlled manner. The overall experience of using this tool is good. [9]

The media rich animations are helpful for learning data structure, for this they create Elli's model. [11]

AETA means Algorithm Explanation Teaching Agent. It is an intelligent agent that has better understanding about Algorithm Explanations. [13]

The visualization tool named VIDSAA, Visualization in Data Structure and Algorithms. This tool covered all basic data structure but they didn't visualize advanced data structure. [14]

The lightweight IDE framework allows the user to design dynamic DS visualization. [18]

The another way to increases the interest of students in data structure, for this they design a system in which they arrange online competitions of making games and in this way student learned concepts of DS. [19]

The combined method is good for teaching data structure i.e. traditional way and visualization. The limitation of visualization is they did not actively connect the student in learning. [22]

A visualization tool that visualized basic data structure but this visualization does not have much user control and they do not visualized advanced data structure. [23]

IV. CONCLUSION

This paper presents a literature review on various visualization tool are used from 2001 to 2013. The search was made by using keywords: teaching learning tool of data structure, visualization tools of data structures, etc. This study provides better understanding of visualization tool and also provides knowledge to the beginners who want to work in visualization tools. By investigating advantages and limitations of the existing visualization tool one can generate a better visualization tool or can improved the existing one.

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