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An empirical study on the effect of 3D visualization for project tasks and resources

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ABSTRACT

During software development, project managers (PMs) continually monitor, analyze and control the project schedule. The schedule contains tasks, work items, and resources assigned to carry out the tasks. Current state-of-the-art monitoring involves methods such as Gantt charts and spreadsheets/tables to display and analyze the project schedule, tasks and resources information PMBOK (2004). These methods, however, have certain limitations. It is difficult to see the entire schedule in a single view and analyze the tasks and resources especially in the case of large data. There is also little support for interacting with the data, and the Gantt chart does not show history information and trends. In this paper, we develop an approach that uses 3D visualizations to represent information about project tasks and resources, to overcome the above limitations. To assess our approach, we conduct an empirical study on real-world projects using 42 participants from both academia and industry. We developed a prototype tool named *3DProjView* for the study. The study compared the effectiveness and efficiency of using 3D visualizations versus Gantt chart and tables. The results indicate that participants using 3D visualizations achieved an average of 40% higher accuracy and spent on average 39% less time analyzing project tasks and resources, further indicating that our approach effectively helps project managers in both accuracy and efficiency for monitoring project performance.

1. Introduction

In the planning phase of a project, PMs develop the project schedule. The schedule contains work items, tasks and their sequence, relationships between tasks, and resources assigned to carry out the tasks. A project task may have one or more subtasks. Examples of tasks could be developing the requirements document for a project or setting up a database. A task of setting up a database can have sub-tasks such as defining tables, schemas and views. A task that has sub-tasks is referred to in Microsoft Project (MS Project) as a summary task (Chatfield and Johnson, 2010). Resources are assigned to tasks or sub-tasks. It is possible for a sub-task to be a summary task, but deep nesting is not recommended because it introduces complexity. When assigning resources to tasks, PMs determine whether the resource will work full time or part time; MS Project uses the term "units" to indicate full or part time work. For example, if a PM wants to indicate that all person time is devoted to the project, the "unit" value for that person is 100% which is also the maximum one can assign. If the person works 8-h days, he or she will be over allocated if any combination of assignments exceeds 8 h (100%) of the available work day. If the person works 8-h days and has 75% unit value of his or her time devoted to the project, then he or she will be over allocated if any combination of assignments equals more than 6 h (75%) of the available work day.

Currently, many PMs utilize Gantt charts to display and analyze the project schedule. The Gantt chart is a two-dimensional chart; it displays project tasks as bars in a timeline and also shows the sequencing and dependencies between them as links. Progress is sometimes shown by shading the bar proportionally to the percent of duration or work completed (see Fig. 1). PMs use Gantt charts, for example, to see task duration, the expected time to finish the task, the percentage of completion, and remaining duration. Spreadsheets or tables are also used by PMs to display project information. They are, however, developed in an ad-hoc way and there is neither agreement on the format nor data presented by them. MS Project, for example, uses them to display tasks and resources information. It has a resource sheet and resource usage sheet that displays information on resources. The resource

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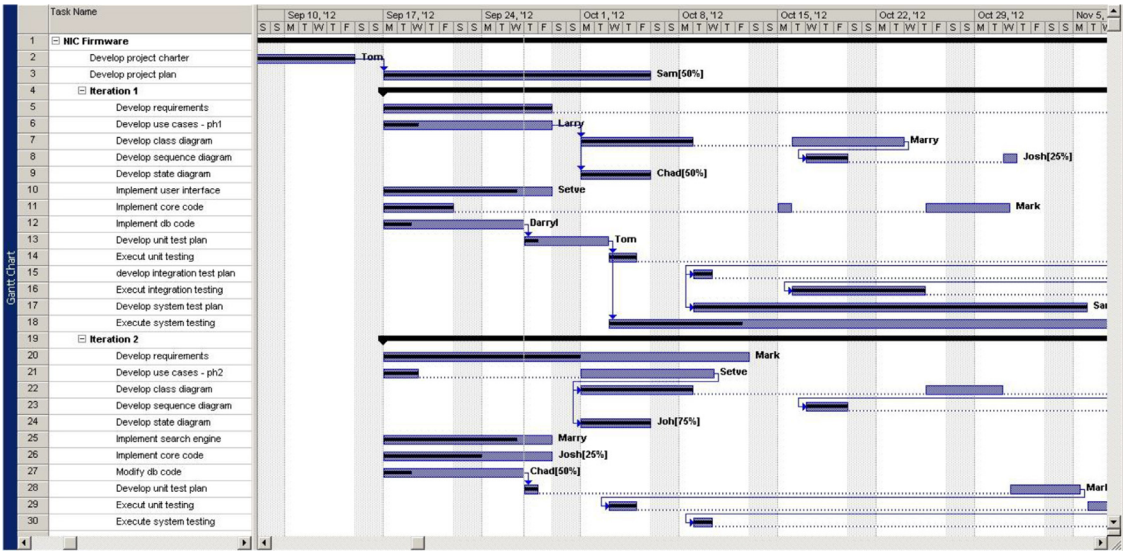

Fig. 1. Examples of Gantt chart above produced using MS Project.

sheet contains information about the resource such as the name, the max unit of work that the resource can spend on the project, the cost per hour, etc. The resource usage sheet, however, shows the amount of work the resource spent on each task assigned to him or her at any point in time since the start of the project. PMs use spreadsheets/tables to track and analyze the status of resources. MS Project also contains a complete list of information that a project can have for a resource or a task (Chatfield and Johnson, 2010).

Previous work identified and tried to overcome some limitations with the Gantt chart. Leach (2010) pointed out that in a Gantt chart, it is very difficult to see the entire schedule, key performance information, past history, trends and future trends for prediction. To overcome some of these limitations, it was suggested that the area underneath the timeline be used to show key information, and zooming and animation be used to show the change in schedule over time. Leach proposes using the Gantt chart to show key performance information with respect to the schedule and budget. We believe budget information should be presented in spreadsheets or other charts (e.g., pie charts). Liston et al. (2000) suggested overlaying information on the Gantt chart to show differences and variance in schedule. Tory et al. (2013) used "shadows", sidebar views, and TbarView to show the variances and overlapping of two schedules. The TbarView has a file selection panel and a widget panel that displays the compared schedules. It also has a Tbar, comparison bar, that has a box that users drag to select the range of schedule they need to compare. They also use different line styles, line color, and icons to display new constraints between project tasks. The Gantt chart provides technical detail about a schedule and does not necessarily require addition information added to it as they are technically out of their scope. The focus of this paper is not to add more information to Gantt charts as proposed by Leach and others above, rather it is to provide PMs a holistic view to look at the status of a project and answer important questions about the project status without flipping around many different tables and/or charts.

The work in this paper is aimed to support the project management of software systems. It presents project tasks, resources and past history information using three 3D visualizations. The visualization displays the information in a single view using 3D space. It uses hierarchical boxes and their dimensions (*x, y*, and *z*), color, and texture to present the information. The paper also reports results on an empirical study showing that the 3D visualizations to analyze project tasks, resources and past history was more effective than using Gantt charts and spreadsheets/tables. To conduct the study, we developed a prototype tool called *3DProjView*. The tool is used to generate three 3D visualizations that are used in the study.

The main contributions of this paper are as follows:

- 3D visualizations to support project management of software systems.
- A 3D visualization model that identifies relationships between project tasks, resources and history information.
- Representing key project management metrics using dimensions *x, y, z*, as well as color and texture.
- Empirical study indicating PMs better interact with the data using 3D space, zoom in-out, detailed-on-demand, and rotation capabilities.

This paper is structured as follows. In Section 2 we present related work in software visualization and project management visualization and describe how our work is different. Section 3 presents our approach in greater detail. Section 4 discusses the empirical study conducted comparing our approach to Gantt charts and tables. In Section 5 we conclude our work and give directions for future work.

2. Related work

In this section, we first present research in software visualization to support the development of software systems followed by research using visualizations to support the project management of software systems. We provide relevant work in both areas as some of the visualization concepts in our work derive from the software visualization literature: i.e., hierarchical layout to present information.

2.1. Software visualization

Boccuzzo and Gall (2007) provide a tool called CocoViz that uses three different metaphors (house metaphor, table metaphor and spear metaphor) to represent entities in software architecture. The house metaphor represents software entities such as classes as houses. The width of the house represents the number of functions in the class while the height of the house represents the number of lines of code. The table metaphor also represents software entities