1. Name and address:

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2. Description of the domain, task, and dataset:

This analysis project is to use different existing information visualization software packages to visualize data sets collected during the execution phase of a construction project, which is related to the change order of the project. The domain, task, and dataset of this analysis project are described in the followings.

1) *Domain*

In a normal construction project, the facility owner hires architects and engineers to design the facility and monitor the construction process. Also there is a general contractor chosen to build the facility according to the design. Due to the usual omissions or mistakes of designs, unexpected environmental conditions, and owners' changing needs of the facility, many alterations of planned construction work are required during the construction phase. This change is normally initiated by contractors when they find discrepancy between actual conditions and design conditions assumed by clients. Usually the contractor will first submit the RFI (request of information), and then the architect or the engineers will reply by issuing SI (site instruction). If the discrepancy is admitted by architects and engineers and reflected on the SI, the contractor will start to prepare a request of additional cost and time extension by submitting request of change orders. In addition to the discrepancy-caused change orders, sometimes the owner will make architect or engineers change original designs, hence another type of change orders will be generated due to the design changes. Whenever there are change orders, contractor-initiated or owner-initiated, impacts on project cost and schedule are always generated. Usually the owner would assume the additional cost and time by approving the submitted requests of change orders. However, sometimes the owners disagree with the amount of responsibility and reject the request, hence underlie the future claim.

The major issues center on the so called "change management" are to minimize the cost impact resulting from changes, minimizing changes, reducing claims, and reducing the cost of responding to rejected change orders. For the aforementioned management functions, there is corresponding information required for executing them. Unfortunately, the information is hidden in large amount of unstructured data like RFIs, SIs or daily site reports. As a result, it is difficult to identify information so as to manage changes effectively. Therefore, the information visualization techniques appear to be a solution for efficiently and effectively extracting information.

The intriguing and high level questions, from the general contractor's perspective, regarding managing changes may include:

a. Supporting the minimization of cost impact

- What are the timings and causes of different types of change orders in different types of projects?
- Where are the data that can justify our request of additional cost and time?

- Is there any hidden cost?
- What is the attitude of the client or architects toward dealing with change orders and possibly subsequent claims?

b. Supporting the minimization of changes

- Will the change itself generate other changes?

c. Supporting the minimization of claims

- Where are the data that can justify our request of additional cost and time? How are we going to present them in an effective way?
- Is there any disadvantageous and unfair contract clause that prohibits us from requesting additional cost and time?

d. Supporting the minimization of cost of responding to rejected change orders

- Do I have the chance to win the claim? What is the cost and benefit of filing a claim?
- Where are the data that can justify our claims?

2) ***Task***

Due to the limited data at hands and time constraints, this analysis project can not answer all the questions posed in this proposal. Although this project is supposed to prove the benefit of information visualization by exploring more interesting information in much shorter time, it is also to identify principles, features, techniques, and scenarios of using information visualization that betters the information extraction in the change management domain. The tasks of this analysis project are threefold:

a. Selection of information visualization solutions

Analyze the characteristics of datasets at hand and possible analytic tasks related to domain questions in order for selecting visualization tools. And then search and identify suitable information visualization software.

b. Exploratory data analysis

Use current industry practice (Excel) and selected tools to analyze limited datasets at hand to answer as many questions posed in the domain description as possible.

c. Critique the current practice and information visualization solutions

Analyze the pros and cons of each tool with respect to different analytic tasks and datasets. By investigating suitable features of tools, we can also draw conclusions regarding good practices and principles of visualizing change management related data. Also cost/benefit comparisons between Excel and information visualization solutions will be conducted.

3) ***Dataset***

The dataset available are spreadsheet data that the construction staff organizes from paper forms of change orders registry, site instruction, and request of information. The names and types of data items are the followings:

a. Change Order (meta-data)

- Change Order Number (ordinal type)
- Reference Number (nominal type)
- Date Issued (ordinal-temporal type)
- Date Approved (ordinal-temporal type)
- Projected Change Order Cost (quantitative type)
- Approved Change Order Cost (quantitative type)
- Trades Related Change Order (meta-data)
  - Sub-trade name (nominal type)
  - Revision Number (ordinal type)
  - Change Order Cost (quantitative type)
- Description (nominal type; need preprocess)

b. Site Instruction (meta-data)

- Site Instruction Number (ordinal type)
- Originating Consultants Name(quantitative type)
- Descriptions (nominal type; need preprocess)
- Attachments (nominal type)
- Date Issued (ordinal-temporal type)
- Remarks (nominal type)

c. Request For Information (meta-data)

- Request For Information Number (ordinal type)
- Descriptions (nominal type; need preprocess)
- Date Sent (ordinal-temporal type)
- Date Due (ordinal-temporal type)
- Date Replied (ordinal-temporal type)
- Comments (nominal type)

3. Personal expertise:

My previous education focuses on engineering aspects of general construction. But my nearly 10 years of work is spent in government dealing with construction management related issues. Change order management is a small fraction of them especially in a country that is not litigious. Basically, both the information visualization and change management are not my expertise, and I start from scratch after I took the research assistant job and commenced my Ph.D. program in 2006. However, because of having experienced different management environment and obtained related knowledge, I find the smooth progress of researching the thesis topic of "Visualization of Construction Project Data".

4. Proposed infovis solution:

The selection of infovis solutions depends on the nature of datasets and information tasks. For example, because the datasets is limited due to the construction industry practice, we need to group the data at hand as surrogates of other data. For example, if the client did not reply or approve by the time stipulated in the contract, the change order or site instruction can be seen

as ineffective. So by observing the differences between filed date and replied date, we can derive other data items of effective SI and ineffective SI. The preliminary analysis of datasets and information tasks alike leads me to choose information visualization tools that at least have the following features:

1) Simultaneously load and show multidimensional data at users' demand. The dimensions supported should be around 10~25.
2) Order data items at users' demand.
3) Have many diagrams that support a variety of statistical analysis.
4) Group and derive new data items.
5) Visually sort, filter data.
6) Layouts of images and visual symbols of images are meticulously configured for capitalizing on human perception ability.

Therefore, the possible visualization tools could be the commercial software packages like Tabeleau, Tablelens, Spotfire, ILOG, and CFX graphics. However, due to the commercial license requirement, only Tabeleau, ILog, and CFX graphics can possibly be available. I hope other essential and available tools might emerge during the course of conducting task **a**.

5. Scenario of use

The user interface is based on what the software can offer, and I will not alter and create any our own interface.

Since the scenario of use is restricted by software interfaces and features, I will conduct the different scenario simulation during the "exploratory data analysis" phase according to different software, tasks and datasets.

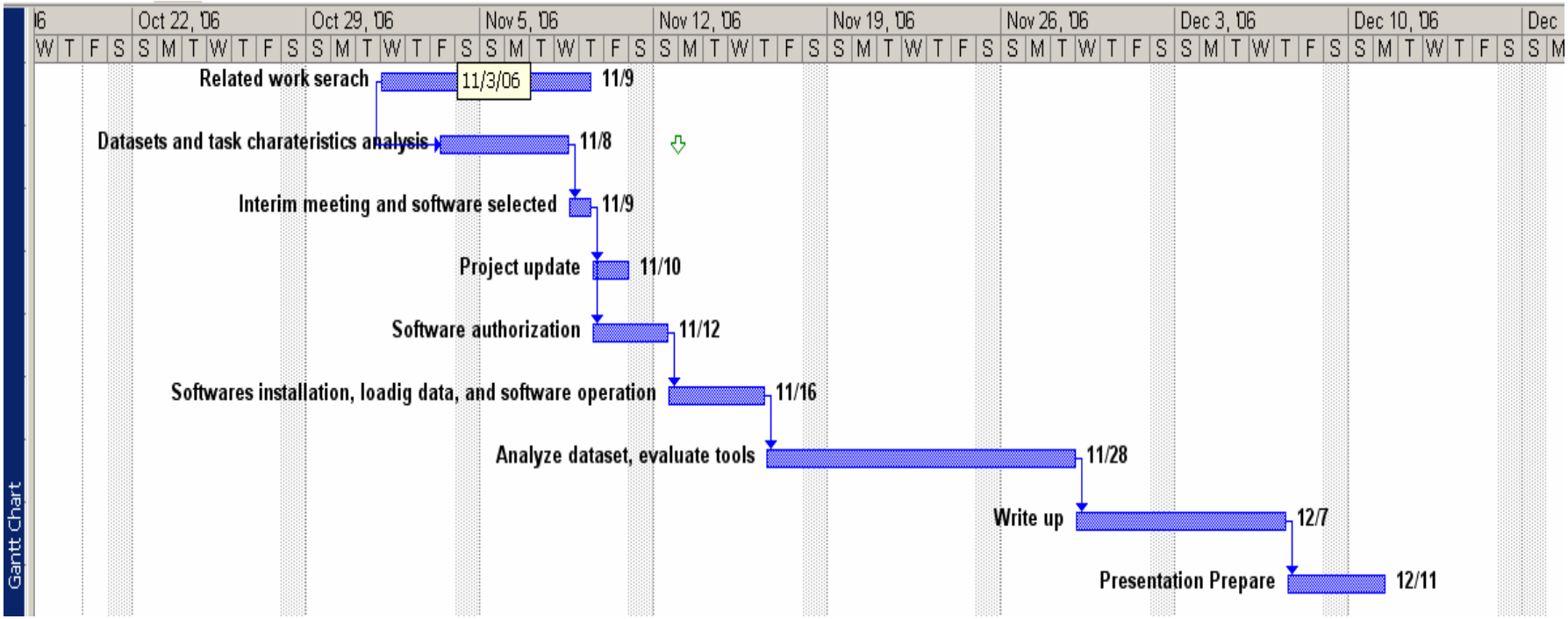
6. Implementation approach

This analysis project does not involve implementation process. However, a lot of efforts will be put on processing domain data format to accommodate software's specification of importing data.

7. Previous Work:

In [4], researchers use monthly cost report data of the earth work, which has the dimensionality of 9, and Treemap to conduct the research. In [2], researchers use juxtaposition of diagrams to visualize multidimensional construction control data. In [3], researchers use linear planning chart to enhance the visualization of project scheduling. In [1], researchers use 3D bar charts, colors, and shapes to visualize construction risks and change orders. Since there are very few similar works done in the construction field, I shall seek related work done by business or manufacturing industry for project guidance.

8. Milestones:



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2. Russell, A. D., Udaipurwala, A. (2000). "Visual Representation of Project Planning & Control Data", Proceedings of the Eighth International Conference (ICCCBE-VIII) - Computing in Civil and Building Engineering, Stanford University, August 2000 - Vol 1, 542-549.
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